UNIT 2

Waste Management

Source Reduction, Recycling, Composting, Landfilling, or Combustion

In this unit, teachers and students will learn the basics of the common solid waste management options used in the United States today. They will learn how to prevent waste before it is even created (known as source reduction), the mechanics and benefits of recycling and buying recycled products, how to make and use compost, and the realities of waste disposal through landfilling and combustion. By learning that trash doesn't just "go away," students will gain an appreciation for how their everyday actions and decisions affect the environment.

CHAPTER 2.1

Source Reduction

Teacher Fact Sheet: Source Reduction 79

Discovering Nature's Packaging (Grades K-1) 83

Reuse: Not Just for the Birds (Grades K-4) 85

Source Reduction Roundup (Grades 3-6) 87

Ecological Picnic (Grades 3-4) 91

How Much Lunch Is Left Over? (Grades 5-6) 95

Grade • Subject • Skills Index

	Activity Name	Discovering Nature's Packaging	Reuse: Not Just for the Birds	Source Reduction Roundup	Ecological Picnic	How Much Lunch Is Left Over?
Grade Range	K	✔	✔			
	1	✔	✔			
	2		✔			
	3		✔	✔	✔	
	4		✔	✔	✔	
	5			✔		✔
	6			✔		✔
Subjects Covered	Math				✔	✔
	Science				✔	✔
	Language Arts			✔		
	Social Studies				✔	
	Art	✔	✔			
	Health					
Skills Used*	Communication			✔	✔	
	Reading					
	Research					
	Computation				✔	✔
	Observation/ Classification	✔		✔	✔	
	Problem Solving					✔
	Motor Skills	✔	✔			

*See Glossary of Skills for more details.

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	4		✔	✔	✔	
	5			✔		✔
	6			✔		✔
Subjects Covered	Math				✔	✔
	Science				✔	✔
	Language Arts			✔		
	Social Studies				✔	
	Art	✔	✔			
	Health					
Skills Used*	Communication			✔	✔	
	Reading					
	Research					
	Computation				✔	✔
	Observation/ Classification	✔		✔	✔	
	Problem Solving					✔
	Motor Skills	✔	✔			

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Source Reduction

What Is Source Reduction?

Americans crave convenience—but at what cost? American households have more discretionary income than most households worldwide, spending more on products that create more waste. Over the last 40 years, the amount of waste each person creates has almost doubled from 2.7 to 4.4 pounds per day (that is 1,606 pounds per person per year!) (EPA, 2003). Though reusing, recycling, and composting are all important methods of reducing the amount of waste produced, the most effective way to stop this trend is by preventing the production of materials that could become waste.

Source reduction, also known as **waste prevention,** is the practice of designing, manufacturing, purchasing, or using materials (such as products and packaging) in ways that reduce the amount or toxicity of waste. Source reduction can help reduce waste disposal and handling costs because it avoids the costs of **recycling**, municipal **composting**, **landfilling**, and **combustion**. It also conserves **natural resources** and reduces **pollution**. In 2000, Americans source reduced (prevented) 55.1 million tons of solid waste (EPA, 2003)

Preventing waste before it is generated is a common-sense way to save financial and natural resources, as well as reduce pollution. That is why EPA encourages consumers, businesses, and governments to make source reduction their first priority in waste management practices. For waste that cannot be prevented, recycling and composting are the next best choices. (See the Teacher Fact Sheet titled *Recycling* on page 101 for more information on recycling.)

Waste is generated throughout the life cycle of a product—from extracting raw materials, to transporting materials, to processing and manufacturing goods, to using and disposing of products. Manufacturers that reuse materials in the production process or that use less material to manufacture products can decrease waste dramatically. Other ways that manufacturers practice source reduction include:

- Reduce the amount of packaging in the manufacture of items.
- Reduce the amount of toxic components in a product or use smaller quantities of items with high toxicity.
- Reuse parts in the manufacture of a product.
- Redesign products to make them more modular. This allows broken or unusable components to be replaced rather than discarding the entire item.

Source Reduction Facts

- Since 1977, the weight of 2-liter plastic soft drink bottles has been reduced from 68 to 51 grams each. That means that 250 million pounds of plastic per year has been prevented from becoming part of the waste stream.
- When McDonald's reduced its napkin size by 1 inch, the company prevented 12 million pounds of paper from being thrown away each year. In 1999, McDonald's switched to lighter weight packaging for two of their sandwiches, conserving 3,200 tons of boxboard containers.
- State Farm Mutual Auto Insurance converted to electronic cameras for their claims processing, saving more than 50 tons of instant and 35mm film.

(Source: EPA, 1996, 1999)

In addition to reducing the amount of materials in the solid waste stream, reducing waste toxicity by selecting nonhazardous or less hazardous materials for manufacturing is another important component of source reduction. Using less hazardous alternatives for certain items (e.g., cleaning products, pesticides), sharing products that contain hazardous chemicals instead of throwing out leftovers, reading label directions carefully, and using the smallest amount of a chemical necessary are some ways to reduce waste toxicity. (See the Teacher Fact Sheets titled *Solid Waste* on page 47 and *Hazardous Waste* on page 51 for information on safe household hazardous waste practices.)

Source reduction is a challenge requiring creativity and ingenuity, but devising ways to prevent waste can be very satisfying and even fun! There are many ways consumers can practice source reduction. Here are just a few examples:

- Choose products that do not use excessive packaging.
- Buy remanufactured or used items.
- Buy items in bulk rather than multiple, smaller packages to decrease the amount of packaging waste created.
- Maintain and repair durable items.
- Reuse bags, containers, and other similar items.
- Borrow, rent, or share items that are used infrequently.
- Donate items instead of throwing them out.
- Leave grass clippings on the lawn (**grasscycling**) or use them for **backyard composting**.
- Rake fallen leaves for composting rather than bagging them and throwing them away.

What Are the Benefits of Source Reduction?

Reducing waste at the source is the ultimate environmental benefit. It means waste does not have to be collected, handled, or processed in any way, which prevents pollution, saves energy, and saves money. In addition, by reducing consumption, fewer products are manufactured, thus reducing the impacts that manufacturing can cause. For example, by manufacturing less, **greenhouse gas** emissions are reduced, which can make a difference in preventing **global climate change**.

Preventing waste also can mean economic savings for communities, businesses, schools, and individual consumers. Many communities have instituted "pay-as-you-throw" waste management systems in which people pay for each can or bag of trash they produce that requires

disposal. When these households reduce their waste at the source, they create less trash and, consequently, pay a lower trash bill.

Businesses also have an economic incentive to practice source reduction. Manufacturing costs can decrease for businesses that reduce packaging, which can mean a larger profit margin and savings that can be passed on to the consumer.

Schools also can share in the economic benefits of source reduction. Buying products in bulk frequently means a savings in cost. Often, what is good for the environment is good for the pocketbook as well.

What Are the Challenges of Source Reduction?

Practicing source reduction is likely to require some change in daily routines. Changing some habits may be difficult, but the environmental returns on the effort can make it worthwhile. For example, while using disposable utensils might be convenient, using durable flatware saves resources and requires only slightly more effort (for cleaning). On the other hand, if waste is not reduced, the economic and social costs of waste disposal and the environmental impacts throughout the life cycle of products will continue to grow, and it will become increasingly harder to make decisions about waste management.

Even if consumers decide to change their consumption habits, products with minimal packaging and nontoxic ingredients are not always available. Balancing the immediate convenience of easily available products with the long-term benefits of waste prevention will be an ongoing commitment.

What Are Some Emerging Trends in Source Reduction?

Many companies are becoming more involved in source reduction by remanufacturing and reusing components of their products or the entire product. A toner cartridge for a laser printer is an example of a product that once was disposable but now is manufactured to be reused. Many products are manufactured to use "modular," or replaceable, units.

One manufacturer of photocopy machines takes back and remakes equipment from more than 30,000 tons of used photocopiers. Parts from returned machines that meet internal criteria for manufacturing are reprocessed into new products. Parts that do not meet remanufacturing criteria and cannot be repaired are often ground, melted, or otherwise recycled into basic raw materials. The company estimates annual savings of several hundred million dollars in raw material, labor, and disposal as a result of design changes and product return programs.

Other companies are also taking advantage of more environmentally preferable ingredients as ways to reduce the weight of packaging. Some supermarkets across the country have instituted shelf-labeling programs to highlight products with less packaging or less toxic ingredients. Purchasing these items shows manufacturers that consumers encourage and support source reduction.

How Can You Help?

Students can play an important role in protecting the environment by practicing source reduction. Here are some simple practices to help prevent waste:

- Donate old clothes and other household items so they can be reused or sold for reuse.
- Consider taking a thermos of juice to school instead of individual disposable containers.
- Use concentrated products to get more product with less packaging.
- Use double-sided copying and printing features.
- Buy pens, pencils, toothbrushes, and other items with replaceable parts.

- Use a durable lunch container or bag instead of a disposable one.
- Consider using environmentally preferable cleaning products instead of those that contain potentially toxic ingredients.
- Consider buying items that have been remanufactured or can be reused, such as toner cartridges for the printer or tires for the car.
- Encourage companies to reduce unnecessary packaging and the use of hazardous components in products. Many companies offer toll-free numbers and Web sites for these comments.
- Compost cafeteria food waste and use the finished compost to mulch the plants and trees around the school grounds.

Additional Information Resources:

Visit the following Web sites for more information on source reduction and solid waste:

- U.S. Environmental Protection Agency (EPA): <www.epa.gov>
- U.S. EPA, Office of Solid Waste site on source reduction: <www.epa.gov/epaoswer/non-hw/muncpl/reduce.htm>
- U.S. EPA, Office of Solid Waste site on global climate change and waste reduction: <http://yosemite.epa.gov/oar/globalwarming.nsf/content/actionswaste.html>
- Reuse Development Organization: <www.redo.org>

To order the following additional documents on source reduction and municipal solid waste, call EPA toll-free at (800) 490-9198 or look on the EPA Web site <www.epa.gov/epaoswer/osw/publicat.htm>.

- *Planet Protector's Club Kit* (EPA530-E-98-002)
- *A Collection of Solid Waste Resources* on CD-ROM
- *Reusable News* newsletters
- *National Source Reduction Characterization Report for Municipal Solid Waste in the United States* (EPA530-R-99-034)
- EPA's WasteWise program puts out *Bulletins* and *Updates* that deal with source reduction. To obtain applicable issues, call the WasteWise helpline at 800 EPA-WISE (372-9473) or visit the Web site at <www.epa.gov/wastewise>.

Art

Discovering Nature's Packaging

Objective

To teach students that some food items come in their own natural packaging.

Key Vocabulary Words

Packaging
Compost

Activity Description

Circle and color the items that have their own natural packaging.

Duration

1 hour

Materials Needed

- Copies of the *Find Nature's Packaging* worksheet for each member of the class
- Crayons or markers

Skills Used

Observation/classification
Motor skills

Activity

Step 1: Discuss how some food products have their own natural packaging that protects the part people eat. If possible, bring in examples of items that have natural packaging (e.g., bananas, unshelled nuts, oranges) and others that do not (e.g., cheese, crackers, soda). Discuss how nature's packaging can be used in compost, which returns materials to the earth. Refer to the Teacher Fact Sheet titled *Composting* on page 141 for background information on the composting process.

Step 2: Distribute the *Find Nature's Packaging* worksheet and pass out crayons or markers. Ask the students to circle the items that have natural packaging.

Step 3: Ask the students to color the items on the worksheet.

Assessment

1. Ask students what items have their own packaging.
2. Ask students what we can do with natural packaging instead of throwing it away.

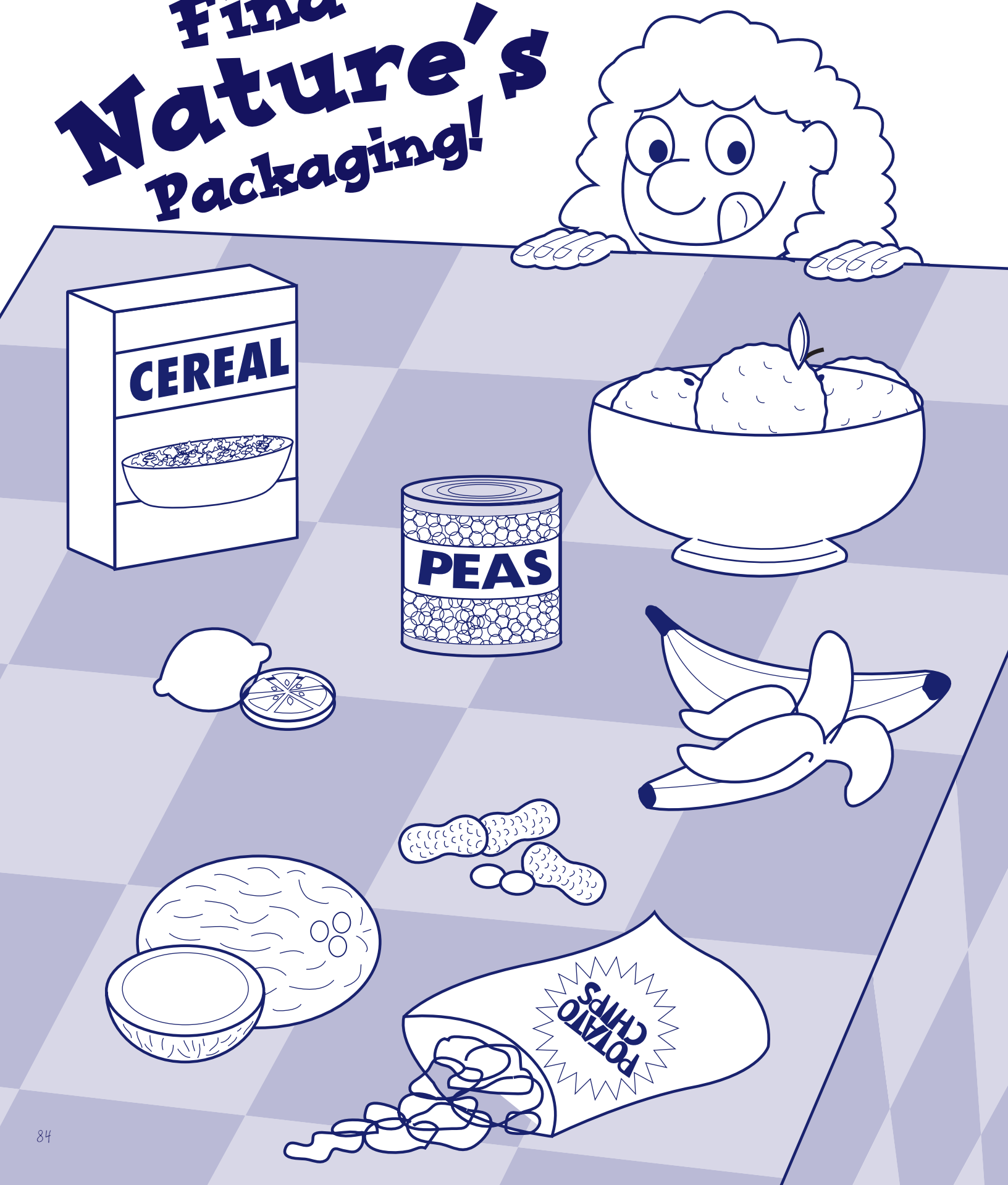
Enrichment

1. Start a vermicomposting bin in the class to demonstrate how nature's packaging can be recycled rather than thrown away. (See the activity *Worms at Work* on page 159 in the Compost chapter for instructions on how to start a vermicomposting bin.)
2. Bring in a variety of unshelled nuts (e.g., pistachios, walnuts, peanuts). Draw or find a sketch of a face, animal, or a fun object. Photocopy it and give one to each student. Have the students shell the nuts and then glue the shells to the sketch. Use paints to color the picture once the glue has dried.

Student Handout

Name:_____

Find Nature's Packaging!



art

Reuse: Not Just for the Birds

Objective

To teach students that, with some creativity, we can make useful things from items we might ordinarily discard in the trash or recycling bin.

Activity Description

Students will bring in plastic milk jugs to create bird feeders.

Materials Needed

- Extra plastic milk jugs (with caps) for students that do not bring in one from home
- Glue
- Scissors
- Paint
- Colored markers
- Two 1-foot long pieces of wood approximately 1/4- to 3/4-inch in diameter (per bird feeder)
- Bird feed for students to put in their finished feeders

Key Vocabulary Words

Reuse
Recycle
Source reduction

Duration

1 hour

Skills Used

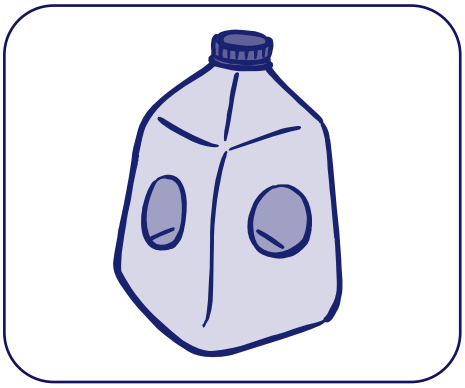
Motor skills

Activity

Instruct students ahead of time to bring in an empty plastic milk jug from home.

Step 1: Introduce the concept of source reduction to the class. Explain that reusing items is a great way to achieve source reduction. (Refer to the Teacher Fact Sheet titled *Source Reduction* on page 79 for background information.)

Step 2: With an adult's supervision or help, instruct students to cut out two large holes on different sides of their milk jug for birds to enter.

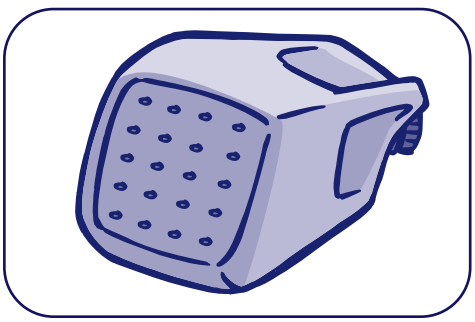


Journal Activity

Have students write a story from the point of view of a bird. What does the bird think of all of the trash it sees from the sky?

Step 3: Provide each student with two 1-foot-long pieces of wood. These could be sticks from a nearby park or even the school grounds. Explain that these wooden pieces will cut through the bird feeder and stick out on either end so that birds can perch on the feeder. With an adult's supervision or help, instruct students

to trace a circle below each of the large holes on the milk jug to match the diameter of the stick. Then, cut out the tracing and insert the wooden pieces through the milk jug.



Step 4: Punch small holes in the bottom of the jug to allow rain water to drain out. Tell students to make sure the holes are not too large, or else the feed might fall through.

Step 5: With markers and/or paints, work with the students to decorate the feeders.

Step 6: Have each student put bird seed in their feeders. Tell the students they can take their feeders home or hang them outside the school.

Assessment

1. Have students name items that can be reused without any alterations. Ask them to list items that can be changed to create a new product (like the bird feeder just created from the milk jug).
2. Ask students to explain why reuse is good for the environment.
3. Ask students what would have happened to the milk jug if it hadn't been used to make the feeder.

Enrichment

1. Organize a waste exchange—with just the class or the entire school. Ask students to bring in something from home they no longer need (e.g., a toy, game, piece of clothing). With teacher facilitation, students can then trade one item for another. Donate unwanted items to a local charity or thrift store.
2. Have students bring in small pieces of "junk" they think look interesting or colorful (e.g., bottle caps, colorful pieces of paper, wood scraps, toy parts, lids, old keys, pieces of old clothing). Then, have the class work together gluing them onto a large piece of wood creating a colorful, attractive mosaic. When the "junk" mosaic is finished, hang it on the wall of the classroom.
3. Instruct students to bring items from home that their families are reusing. Have the students present these items to the class as a "show and tell."

Source Reduction Roundup

language arts

Objective

To teach students the various ways to create less waste in the first place.

Activity Description

Students form teams and work together to answer questions on source reduction.

Materials Needed

- *Source Reduction Questions and Answers* sheet
- Chalk board or flip chart
- Clock or timer

Key Vocabulary Words

Reuse
Source reduction
Disposable
Pollution
Natural resources

Duration

1 hour

Skills Used

Communication
Observation/classification

Activity

Step 1: Discuss source reduction and reuse and how it relates to a clean and healthy environment. Explain what individuals can do to make a difference in the amount of waste that is created. (Refer to the Teacher Fact Sheets titled *Source Reduction* on page 79 and *Products* on page 25 for background information.)

Step 2: Divide the class into two teams. Bring the two teams to the front of the classroom and have them face each other. You might want to line up a row of desks on each side to create a "game show" setting. Flip a coin to decide which team will go first.

Step 3: In preparation for this activity, write the questions on a flip chart, or simply write them one at a time on the board. Present the first question to Team 1. Inform students there are a certain number of answers to this question. The number of correct answers is provided on the attached *Questions and Answers* sheet. Instruct Team 1 that they can consult for 2 minutes before they must try and provide as many of the six answers as possible.

Step 4: As the students in Team 1 state their answers, write them on the board below the question.

Step 5: Team 1 gets a point for every correct answer. If Team 1 was unable to get all six answers referred to on the *Questions and Answers* sheet, then Team 2 gets an opportunity to guess the rest of the answers for that same question. Write Team 2's answers on the board next to Team 1's answers. If Team 1 was able to provide all of the correct answers, then Team 2 doesn't get a chance to answer that question.

Step 6: Go over the answers with the class and discuss any answers that neither team could provide.

Journal Activity

Ask students to make a list of all the things they currently do that create less waste. Then ask them to list other things they could do to further reduce the amount of waste they produce in their daily routines.

Step 7: Start the process over again with question #2, but this time, allow Team 2 to answer first. Keep track of the score and work through all of the questions, alternating which team gets to answer first.

After all of the questions have been answered, the team with the most points wins. For extra credit, see if students can name even more correct answers.

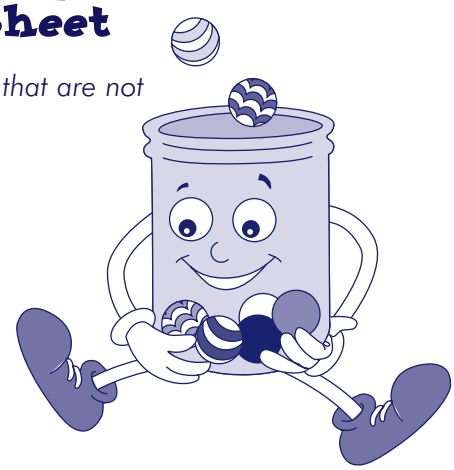
Assessment

1. Ask students what kinds of activities are involved in source reduction.
2. Have students list some things each of us can do to create less waste and reuse more.
3. Ask students to explain why source reduction is important.

Enrichment

1. Have each team of students devise its own questions and answers for the opposing team, and play again.
2. Organize a clothing drive with the class or the entire school. Donate the used clothing to a local charity or thrift store.

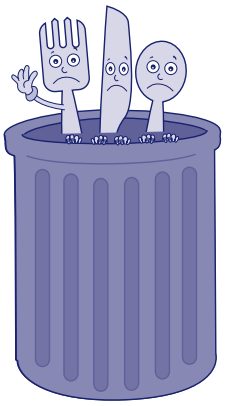
Source Reduction Roundup Questions and Answers Sheet



(Note: Students should be encouraged to think of additional responses that are not on these lists.)

What are 6 ways you can reuse a jelly jar?

1. Pen and pencil holder
2. Cookie cutter
3. Storage container for leftovers
4. Drinking glass
5. Vase for flowers
6. Container for nonfood items such as paper clips, buttons, marbles, or any other small item



What are 6 commonly used items that are often thrown away but could be reused? (Note that some items have both reusable and disposable parts.)

1. Cups
2. Eating utensils (e.g., forks, knives, spoons)
3. Plates
4. Cloth Napkins
5. Lunch bags
6. Batteries

What are 6 benefits of source reduction?

1. Reduces waste
2. Conserves natural resources
3. Reduces pollution
4. Reduces disposal costs
5. Reduces toxic waste in the waste stream
6. Saves money

What are 6 ways you and your family can reduce waste?

1. Use a reusable bag when shopping
2. Bring your lunch in a reusable bag
3. Buy or make your own nontoxic cleaners
4. Make sure you only buy what you need
5. Donate items you don't need anymore instead of throwing them away
6. Use both sides of paper before recycling it

Ecological Picnic

Objective

To show students that choices they make about products and packaging can have an impact on the amount of waste they generate.

Key Vocabulary Words

Source reduction
Durable
Nondurable

Activity Description

Plan a picnic with students that produces as little waste as possible.

Duration

Day 1: 1 hour
Day 2: 1 hour, 30 minutes

Materials Needed

- Lunch
- Durable or reusable plates, silverware, cups, napkins, etc.
- Recyclables container
- Garbage container
- Food waste container, if your school composts
- Large scale

Skills Used

Communication
Computation
Observation/classification

Activity

Day 1

Step 1: Select a location to hold your ecological picnic, preferably outdoors with an indoor alternative in case of inclement weather. Find three containers the children can use to separate their recyclables, trash, and food scraps after they have finished their picnic lunch. Check with your cafeteria manager to see if your class can use nondisposable silverware, cups, and plates and if arrangements can be made to provide bag lunches for students who forget or are unable to bring a lunch from home.

Step 2: Explain to students that you will be taking them on an ecological picnic where they will learn how to create less garbage, recycle more, and compost their leftover food items. Introduce the concepts of durable and disposable items and source reduction to the class (refer to the Teacher Fact Sheet titled *Source Reduction* on page 79 for background information). Note how students will put these concepts into practice during the picnic.

Step 3: With students, compile a list of items on the blackboard that people usually bring to a picnic (e.g., paper plates, plastic utensils, paper napkins, chips, drinks, sandwiches). Working through the list on the blackboard, discuss items that can replace the disposable items. Examples might include cloth napkins

Journal Activity

Ask students if they saw any litter where they had their picnic. Ask them how it made them feel to see litter. How could it affect the plants, animals, and other people that use the space?

instead of paper napkins or washable plastic plates instead of paper plates. Explain the benefits of buying in bulk by describing how one large bag of popcorn, for example, leaves less garbage than many smaller bags. You can also discuss picnic games and activities and their impact on the environment. Note that tossing a frisbee or flying kites doesn't create any waste, but having a water balloon fight does.

Step 4: Send a note home with the children explaining how to prepare for the picnic. The note should explain that your class is having an ecological picnic and is trying to limit the amount of garbage left over. Encourage students to discuss what they've learned about source reduction with their parents and to help make preparations by placing food in reusable containers or including as little packaging as possible. Parents can also be invited to volunteer for the picnic. You can conduct the picnic in two ways:

A) Children can bring their own lunch.

B) Children can bring "potluck" items. This may require more time and effort from the parents to provide and transport the items. In class, have the children draw up a list of the things they need and have each of them select something to bring. If your cafeteria is unable to provide silverware, cups, and plates, these will need to be provided by students. In the note to the parents, list the item the student has chosen to bring.

Day 2

Step 1: Before the picnic, explain to the students that they will be weighing the amounts of recyclables, trash, and food scraps left over from the picnic. Ask them to guess approximately how many pounds of material they think will be left over in each of the containers after the picnic. Draw the Eco-Picnic Table shown below on the blackboard and enter their guesses in the first

Eco-Picnic Table

	Recyclables	Food Scraps	Trash	Total Guess
Guess				
Actual Weight (with container)				
Subtract Weight of Empty Container				
Total of Each				

row. Show students which container you want them to use for recyclables, trash, and food scraps and then weigh each of the empty containers on the large scale. Record these numbers on the Eco-Picnic Table. Encourage the students to pick up any litter they find at the picnic site.

Step 2: Go to the picnic site and have the picnic.

Step 3: After lunch, discuss the types of garbage that are left over, as well as the garbage prevented because of the choices students made. Have the students look at the leftover garbage and come up with ways they could have reduced it further.

Step 4: Return to the classroom with the containers. Weigh the three containers to determine the amount of material that must be disposed of, recycled, or composted. How close was the students' original guess? Multiplied by 7 days, how much waste would your classroom dispose of in 1 week? How much would it recycle? How much could be composted? Ask your students to discuss, generally speaking, what would happen if the whole school (or even America as a whole) practiced source reduction as they did for the picnic.

1. Ask students why people use disposable items even if they know they make more garbage.
2. Ask students to provide an example of a disposable item that they or their family use regularly. Are there other alternatives that could create less waste? Would they or their family be willing to switch products or change their lifestyles to produce less waste and have less of an impact on the environment?
3. Ask students to think of other ways, beyond a picnic, that they can practice source reduction. Examples might include using cloth napkins and wipes instead of paper towels, buying juice in large bottles or concentrate rather than separate single-serving bottles, using their imagination for games rather than toys, or taking cloth bags when shopping.

1. You could consider conducting this activity by measuring the recyclables, trash, and compostables from a regular day's lunch compared to the ecological picnic lunch.
2. Collect the food scraps left over from the picnic and put them in a vermicomposting bin or compost pile. (Refer to the composting activities section and the Teacher Fact Sheet titled *Composting* on page 141 for more information.)
3. Make fun lunch bags out of an old pair of jeans or shorts. Cut off the legs, sew the bottom closed just under the pockets, and tie thick ribbon through the belt loops for handles. Help students decorate their bags with objects such as buttons, small toys, scrap cloth and ribbon, and fabric paints.

math

science

How Much Lunch Is Left Over?

Objective

To teach students that reducing product packaging can often reduce waste.

Activity Description

Students will weigh their lunches before and after eating to determine how much of their lunch is packaging.

Materials Needed

- Copies of *Packaging Worksheet* for each member of the class
- Resealable plastic bags (approximately 1 quart capacity) for each member of the class
- Small scales capable of weighing items under a pound

Key Vocabulary Words

Source reduction
Recycling
Organics
Composting
Landfills
Disposable

Duration

2 hours

Skills Used

Computation
Problem solving

Activity

Before conducting this activity, ask all students in the class to bring their lunch from home on a selected day. If some students are on a cafeteria lunch program, consult with cafeteria staff to see if they can provide box lunches on a certain day. If box lunches aren't feasible, have the students use the waste from their regular school lunches (e.g., milk containers, plastic packages, paper napkins, cups, etc.).

Step 1: Explain source reduction to the class. Discuss how it is one of the most important activities we can engage in to help the environment. In addition, discuss how packaging is frequently necessary, but can also create a lot of waste. (Refer to the Teacher Fact Sheets titled *Products* on page 25 and *Source Reduction* on page 79.) Distribute a copy of the *Packaging Worksheet* to each student.

Step 2: Before lunch, ask students to list each piece of their lunch (including the lunch bag or container) in Column A, then weigh each item on a scale and record the weights in Column B on their *Packaging Worksheet*. Send them to lunch with their own resealable bag and instruct them to put all packaging from their lunches in the bag instead of the garbage can. Explain that they should save nature's packaging also (e.g., banana peels, orange rinds, peanut shells).

Journal Activity

Ask students to write a story about what their lives and the environment would be like if everything was disposable and they could not reuse or recycle anything.

Step 3: After lunch, have the students weigh each piece of packaging from their resealable bags and record these numbers in Column C.

Step 4: Have the students compare the weight of each piece of their lunches before eating and after. Based on these numbers, calculate the percentage of the total weight that is the packaging for each lunch item.

Step 5: Instruct students to total Columns B and C and put these figures in the "Total" row of those columns.

Step 6: Discuss recycling, composting, and reuse. Have students put a check in the appropriate box for those packaging items that are reusable, compostable, or recyclable. These checks are for information only, showing students what methods could be used as alternatives to throwing out these items. If students couldn't check any of these alternatives, then the total in their final column (H) would be zero. If, however, they can check off any of these (reusable, compostable, recyclable) columns, then that item's remaining packaging weight gets added to column H.

Step 7: Ask students to compare their totals from Columns B, C, and H and share them with the class. Discuss the types of packaging waste they could not reuse, compost, or recycle. Discuss how this waste could be reduced through other actions, such as their purchasing behavior or the design of the packaging.

Step 8: Start a list on the chalkboard of ways students can create less waste in their lunches (e.g., buying in bulk, reusable lunch bags, reusable utensils).

Assessment

Ask students the following questions:

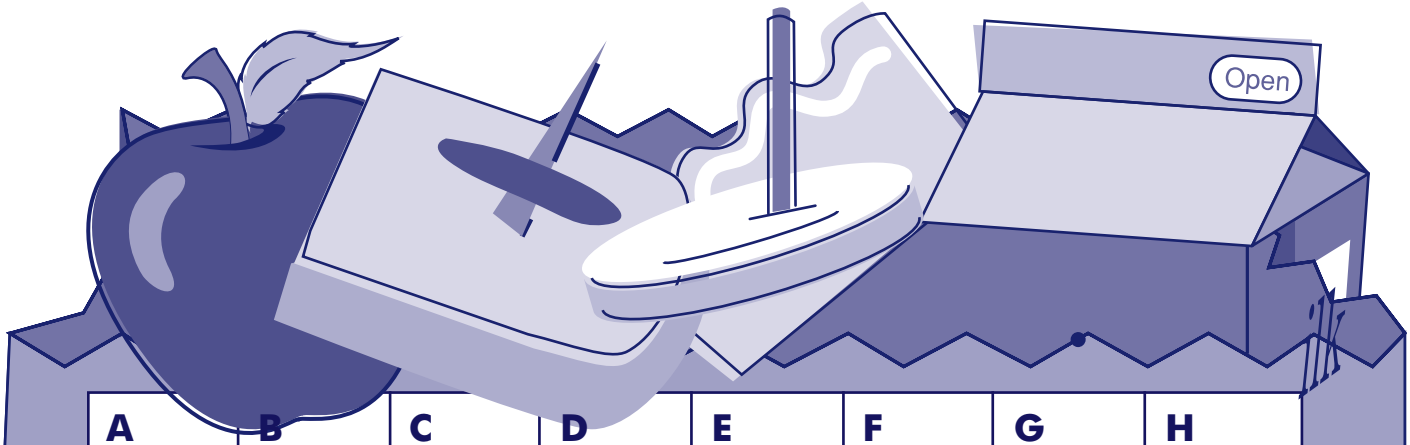
1. Why do manufacturers use packaging?
2. Why did some students have more packaging waste than others?
3. Why do some products have so much packaging?
4. Are there ways to avoid purchasing so much packaging? What are they?
5. Can some packaging be reused or recycled? Which?
6. What is the difference between a disposable and reusable product? What are some examples?

Enrichment

1. Bring in a bulk item and the same amount in individually wrapped single serving containers. Empty the contents of the containers and weigh them. Compare the weights of the one big container to the total weight of the multiple single-serving containers. Discuss what effect the different kinds of packaging have on the environment.
2. Ask students to go to the store and compare the per unit prices of similar items that are packaged differently (e.g., bulk versus individual packages). Instruct them to write down their findings and draw conclusions from them.
3. Have students find a product they believe to be packaged in excess. Ask them to explain why they think the packaging is wasteful. Instruct the students to write a letter or send an e-mail to the manufacturer that sells the overpackaged product asking the company to consider reducing the amount of packaging. Request a response.
4. Instruct students to select a package of their choice and think of ways they could reduce the volume and/or weight of the package without changing its function. Ask students to sketch a rough drawing or write a description of their proposed package and list the reasons why they think the new package would be better.

Packaging Worksheet

Name: _____



A	B	C	D	E	F	G	H
Item From Lunch	Weight Before Eating (Product and Packaging)	Weight After Eating (Packaging)	Packaging %	Packaging Reusable?	Packaging Compostable?	Packaging Recyclable?	Total Amount of Trash That COULD Have Been Avoided.
1. Example: Banana	170 g	28 g	16%		✔		28 g
2.							
3.							
4.							
5.							
6							
7.							
8.							
9.							
10.							
Totals							

CHAPTER 2.2

Recycling

Teacher Fact Sheet: Recycling 101

Teacher Fact Sheet: Buying Recycled 107

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Recycling...Sorting It All Out (Grades 3-6) 125

Designing the Ultimate Can Crusher (Grades 4-6) 129

Learn to Recycle (Grades 7-8) 131

Recycling Includes e-Cycling (Grades 4-8) 135

Grade • Subject • Skills Index

	Activity Name	Recycling Rangers	Follow That Bottle!	Take-Home Recycling Kit	Making Glass From Scratch	Handmade Recycled Paper Planters	Recycling... Sorting It All Out	Designing the Ultimate Can Crusher	Learn to Recycle	Recycling Includes E-Cycling
Grade Range	K	✔	✔							
	1	✔	✔							
	2	✔	✔	✔	✔	✔				
	3			✔	✔	✔	✔			
	4					✔	✔	✔		✔
	5					✔	✔	✔		✔
	6					✔	✔	✔		✔
	7								✔	✔
	8								✔	✔
Subjects Covered	Math				✔		✔	✔		✔
	Science				✔	✔	✔	✔		✔
	Language Arts			✔					✔	
	Social Studies	✔			✔					
	Art		✔	✔		✔			✔	
	Health									
Skills Used*	Communication	✔		✔	✔		✔		✔	✔
	Reading				✔					
	Research						✔	✔	✔	
	Computation						✔	✔		
	Observation/ Classification	✔			✔		✔			✔
	Problem Solving				✔					
	Motor Skills		✔	✔		✔		✔		

*See Glossary of Skills for more details.

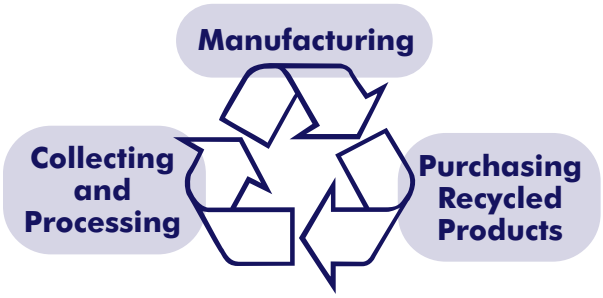
Recycling

What Is Recycling?

Recycling is a series of activities that includes the collection of used, reused, or unused items that would otherwise be considered waste, sorting and processing the recyclable products into raw materials, and remanufacturing the recycled raw materials into new products. Consumers provide the last link in recycling by purchasing products made from recycled content. Recycling also can include composting of food scraps, yard trimmings, and other organic materials. (See the Teacher Fact Sheet titled *Composting* on page 141 for more information.)

How Does Recycling Work?

Many people already recycle items like paper, glass, and aluminum. While these efforts are a vital part of the process, the true recycling path continues long after recyclables are collected from household bins or community drop-off centers. Collecting, processing, manufacturing, and purchasing recycled products creates a closed circle or loop that ensures the overall success and value of recycling.



Collection

How and where recyclables can be collected vary from community to community. Some communities collect from residences, schools, and businesses through:

- Curbside collection programs, the most common method. Residents set recyclables, sometimes sorted by type, on their curbs to be picked up by municipal or commercial haulers.
- Drop-off centers, locations where residents can take their recyclables. These centers are often sponsored by community organizations.
- Buy-back centers, local facilities where recycled-content manufacturers buy their products back from consumers and remanufacture the used products into new products.

- **Deposit/refund programs,** which require consumers to pay a deposit on a purchased product in a container (e.g., bottle). The deposit can be redeemed when the consumer brings the container back to the business or company for recycling.

Processing

After collection, some recyclables are "processed" and prepared for delivery to manufacturing facilities. Processing usually includes making sure the materials are sorted properly and that contaminants (i.e., nonrecyclables) are removed. Recyclables are then usually sent to a ***materials recovery facility*** (MRF, pronounced "murph") to be further sorted and then processed into marketable commodities for remanufacturing. Recyclables are bought and sold just like any other commodity, and prices for the materials change and fluctuate with the market. Each MRF has individual requirements about what materials it will accept, but most accept newspapers, aluminum cans, steel food cans, glass containers, and certain types of plastic bottles.

Follow a Plastic Bottle Beyond the Bin...

After a plastic soda bottle is collected in a recycling bin, it is sorted and transported to a materials recovery facility. There it is cleaned and fed into a granulator that chops it into uniform-sized pieces, called "flakes." A manufacturer then purchases the flakes and melts them, squeezing the plastic into thin spaghetti-like strands and chopping those strands into small pieces called "pellets." These plastic pellets are further stretched and squeezed into thin fibers that can be remanufactured into items like clothing, bags, bins, carpet, plastic lumber, hospital supplies, housewares, packaging, shipping supplies, toys, and more. Consumers then complete the recycling loop by purchasing and using these new recycled-content products.

Manufacturing

Once cleaned and sorted, the recyclables move to the next part of the recycling loop—manufacturing. More and more of today's products are being manufactured with recycled content.

- Recycled cardboard and newspaper are used to make new boxes, papers, and other products such as tissues, paper towels, toilet paper, diapers, egg cartons, and napkins.
- Recycled plastic called PET, found in soft drink, juice, and peanut butter containers, is used to make new products such as carpets, fiberfill (insulating material in jackets and sleeping bags), bottles and containers, auto parts, and paint brushes. Another kind of recycled plastic, HDPE, used in milk, water, detergent, and motor oil containers, can be remanufactured into trash cans, bathroom stalls, plastic lumber, toys, trash bags, and hair combs. Numbers imprinted on the plastic product indicate from which type of plastic the product has been manufactured and how it can be recycled. Not all communities recycle all types of plastic.
- Recycled glass is used again and again in new glass containers as well as in glasphalt (the roadway asphalt that shimmers in sunlight), road filler, and fiberglass.
- Recycled aluminum beverage cans, one of the most successful recyclables, are remade into new cans in as little as 90 days after they are collected. Recycled aluminum cans also can be used in aluminum building materials.
- All steel products manufactured in the United States contain 25 to 30 percent or 100 percent recycled steel, depending on the manufacturing process used.

Recycling in the United States Throughout History

Although the United States has witnessed a major increase in public participation in recycling programs in recent years, industrial and commercial recycling has always made sense economically. The time line below presents a brief glimpse of recycling throughout U.S. history.

Late 1800s to Early 1900s

- Before the days of mass production, the economic climate required people to routinely repair, reuse, and recycle their material possessions.
  - Scrap yards recycled old cars, car parts, and metal goods.
  - The paper industry used old rags as its main source of fiber until the late 19th century.
  - Retailers collected used cardboard boxes for recycling.

1914–1918 and 1939–1945 (WWI and WWII)

- Patriotism inspired nationwide scrap drives for paper, rubber, and other materials to help the war effort.
  - Many farms melted down and recycled iron or metal pieces of rusted machinery for warships, vehicles, and other military machines.
- People even saved grease from meat they cooked, which was used to make munitions.

1960s

- Interest in recycling waned as America's peacetime economy soared. Rising incomes and widespread, affordable, mass-produced goods created the "disposable" society.

1970s

- Environmental awareness rejuvenated the nation's interest in recycling.
- U.S. Environmental Protection Agency (EPA) was established December 2, 1970.
- The first Earth Day was held in 1970, significantly increasing recycling awareness. In the years following, 3,000 volunteer recycling centers opened and more than 100 curbside collection programs were established.
- EPA and some state agencies developed guidelines, technical assistance, and targets for local recycling efforts.

1980s

- The national spotlight fell on monitoring trash due to increased awareness of pollution resulting from poor waste management.
- Federal, state, and local governments became more and more involved in waste management.
- Waste management firms began to offer recycling programs in connection with proposals for new incinerators or landfills.

1990s

- Industry expanded the range of products made from recycled materials instead of virgin raw materials.
- National recycling rate reached double digits (28.2 percent in 1998).

2000s

- EPA sets national goals for reducing and recycling waste.

Recycling Facts

- By recycling 1 ton of paper, we save: 17 trees, 7,000 gallons of water, 463 gallons of oil, 3 cubic yards of landfill space, and enough energy to heat an average home for 6 months.
- Manufacturers can make one extra-large T-shirt out of only five recycled plastic soda bottles.
- Americans throw away enough aluminum every 3 months to rebuild our entire commercial air fleet.
- When one ton of steel is recycled, 2,500 pounds of iron ore, 1,400 pounds of coal, and 120 pounds of limestone are conserved.
- Recycling aluminum cans saves 95 percent of the energy required to make aluminum cans from scratch.
- The amount of aluminum recycled in 1995 could have built 14 aircraft carriers.

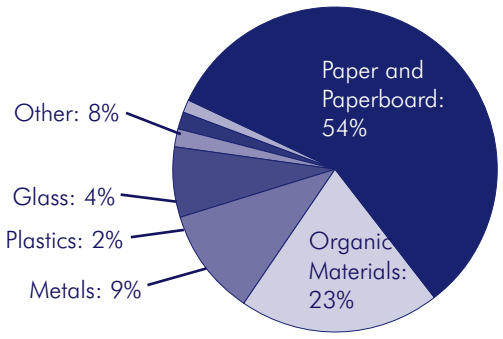
(Sources: Weyerhaeuser Company, 2001; Steel Recycling Institute, 2000; American Forest and Paper Association, 2000; R.W. Beck, 1997; The Can Manufacturers Institute, 1997; Anchorage Recycling Center, 2000; Recyclers' Handbook by Earthworks Group, 1997; EPA, 1997)

Purchasing Recycled Products

The market for recycled materials is the final part of the recycling loop. Recycled products must be bought and used in order for the entire recycling process to succeed.

Recycling and composting activities divert about 62 million tons of material from landfills and incinerators. (See the Teacher Fact Sheets titled *Landfills* on page 165 and *Combustion* on page 169 for more information.) In 2001, this country recycled 29.7 percent of its waste, a rate that has almost doubled over the past 15 years. That's 1.3 pounds per person per day. Of that 29.7 percent, here is the breakdown of what the United States recycled that year:

Materials Recycled in the United States



Source: EPA, 2003

What Are the Benefits of Recycling?

When each part of the recycling loop is completed, the process helps both the environment and the economy. Recycling prevents materials from being thrown away, reducing the need for landfilling and incineration. In addition, the use of recycled materials to manufacture new products prevents pollution caused by the manufacturing of produces from virgin materials. Also, using recycled materials for manufacturing decreases emissions of greenhouse gases that contribute to global climate change. Since the use of recycled materials reduces the need for raw material extraction and processing, energy is saved and the Earth's dwindling resources are conserved.

Recent studies indicate that recycling and remanufacturing account for about 1 million manufacturing jobs throughout the country and generate more than $100 billion in revenue. Many of the employment opportunities created by recycling are in areas of the country where jobs are most needed. Jobs include materials sorters, dispatchers, truck drivers, brokers, sales representatives, process engineers, and chemists.

What Are the Challenges of Recycling?

Despite its success, the potential of recycling in this country is not yet fully realized. Some plastics, for example, such as bottles and containers, are recyclable in almost any community, but others, such as plastic "peanuts" used in packaging, usually can not be included in curbside or drop-off recycling programs. These items still end up in the trash because it is not profitable to collect the tons needed for remanufacture into new products.

In addition, the costs of collecting, transporting, and processing recyclables can sometimes be

Is Your School Waste Wise?

WasteWise is a voluntary EPA partnership program that helps businesses, governments, and institutions reduce waste and save money. Since the program began in 1994, WasteWise partners have reduced their municipal solid waste by more than 26 million tons! In 1998 alone, partners saved an estimated $264 million. Partners include many large corporations, small and medium-sized businesses, hospitals, tribes, and state, local, and federal governments, as well as 87 schools, school districts, colleges, and universities in more than 30 states.

The following are examples of the accomplishments of a few WasteWise partners in the education field. Alden Central School of New York, which educates children from K-12, implemented a comprehensive waste reduction program in all campus buildings. Students and staff eliminated 450 pounds of polystyrene cafeteria trays and dishes by switching to reusable products. They also composted 900 pounds of cafeteria food scraps and 150 pounds of yard trimmings for use as mulch on building grounds. Sligo Adventist School of Maryland also implemented several innovative waste prevention activities including the reduction of more than 1 ton of drink boxes by switching to bulk juice dispensers. Eastern Illinois University reduced the amount of computer paper used on campus by 10 percent and reused 13 tons of office supplies through an internal exchange among employees.

To find out how your school can join the WasteWise program, please call 800-EPA-WISE (372-9473), e-mail at ww@cais.net, or visit the Web site at <www.epa.gov/wastewise>.

higher than the cost of disposing of these materials as waste. The average cost to process a ton of recyclables is $50, while the average value of those recyclables on the market is only $30. Processors often compensate for this discrepancy by charging a set fee for each ton of material they receive or by establishing ongoing contracts with communities or haulers. Efforts to better manage waste and recycling programs are under development. Many communities across the country implement financial incentives to encourage people to recycle. Residents are charged a fee based on the amount of solid waste they throw away. The more a household recycles, the less garbage it throw outs, and the lower the collection fee it pays.

Finally, recycling facilities are not always a welcome addition to a community. As with other waste management operations, recycling facilities are often accompanied by increased traffic, noise, and even pollution. Community leaders proposing the location for a recycling facility can encourage the NIMBY (Not in My Backyard) sentiment.

Additional Information Resources:

Visit the following Web sites for more information on recycling and solid waste:

- U.S. Environmental Protection Agency (EPA): <www.epa.gov>
- U.S. EPA, Office of Solid Waste site on recycling: <www.epa.gov/epaoswer/non-hw/muncpl/reduce.htm>
- Plug-in To e-Cycling: <www.epa.gov/epaoswer/osw/conserve/plugin>
- U.S. EPA, Office of Solid Waste WasteWise Program site: <www.epa.gov/wastewise>
- U.S. EPA, Office of Solid Waste site on global climate change and recycling: <http://yosemite.epa.gov/oar/globalwarming.nsf/content/actionswaste.html>
- U.S. EPA, Office of Solid Waste, Kid's Page: <www.epa.gov/epaoswer/education/kids.htm>
- U.S. EPA, Region 9 Office's Recycling Site for Kids: <www.epa.gov/recyclecity>
- National Recycling Coalition: <www.nrc-recycle.org>
- Institute for Scrap Recycling Industries: <www.isri.org>
- American Plastics Council: <www.plastics.org>
- Steel Recycling Institute: <www.recycle-steel.org/>
- Aluminum Association: <www.aluminum.org>
- Glass Packaging Institute: <www.gpi.org>
- American Forest and Paper Association: <www.afandpa.org>
- Institute for Local Self-Reliance: <www.ilsr.org>
- Rechargeable Battery Recycling: <www.rbrc.org>
- Polystyrene Packaging Council: <www.polystyrene.org>
- Electronic Industries Alliance: <www.eiae.org>

To order the following additional documents on municipal solid waste and recycling, call EPA toll-free at (800) 490-9198 or look on the EPA Web site <www.epa.gov/epaoswer/osw/publicat.htm>.

- *Characterization of Municipal Solid Waste in the United States*
- *Planet Protectors Club Kit* (EPA530-E-98-002)
- *A Collection of Solid Waste Resources*—CD-ROM

Buying Recycled

What Is "Buying Recycled?"

"Buying recycled" means purchasing items that are made from **postconsumer** recycled content—in other words, materials that were used once and then recycled into something else. This process is also known as "**closing the loop**."

Consumers "close the loop" when they purchase products made from recycled materials. After an item has been collected for recycling, sorted and processed, and remanufactured into a new product, it still has one more critical step to undergo: purchase and reuse. If no one buys **recycled-content products**, the entire recycling process is ineffective.

Key Points

- Buying recycled-content products encourages manufacturers to purchase and use recycled materials.
- Buying products with "postconsumer" content closes the recycling loop.
- Not all recyclable products can be recycled in every community.
- Buying recycled products saves energy, conserves natural resources, creates jobs, and reduces the amount of waste sent to landfills and incinerators.
- Today's recycled-content products perform just as well, cost the same or less, and are just as available as their nonrecycled counterparts.
- New products containing recycled materials, from construction materials to playground equipment to computers, are constantly being developed.

How Can People "Close the Loop?"

Consumers hold the key to making recycling work. Many manufacturers are already making the use of recycled materials a part of their official company policy. Through buying recycled-content products, consumers can encourage this trend, making each purchase count toward "closing the loop." Purchasing recycled-content goods ensures continued availability of our natural resources for the future.

The first step in buying recycled-content products is to correctly identify them. As consumers demand more environmentally sound products, manufacturers are encouraged to highlight these aspects of their merchandise. While this trend is good, shoppers should be aware of the various uses of "recycled" terminology. To help consumers understand product claims about recycled content, the

A Recycled Product Shopping List

More than 4,500 recycled-content products are already available in stores, and their numbers are rapidly growing. Some of the everyday products people regularly purchase contain recycled-content. Here are some items that are typically made with recycled materials:

- Aluminum cans
- Cereal boxes
- Egg cartons
- Motor oil
- Nails
- Trash bags
- Comic books
- Newspapers
- Paper towels
- Carpeting
- Car bumpers
- Anything made from steel
- Glass containers
- Laundry detergent bottles

Federal Trade Commission has issued guidelines to ensure that products are properly and clearly labeled. Here are some basic definitions:

- **Recycled-content products** are made from materials that have been recovered or otherwise diverted from the solid waste stream, either during the manufacturing process or after consumer use. Recycled-content products also include products made from used, reconditioned, and remanufactured components.
- **Postconsumer content** indicates that materials used to make a product were recovered or otherwise diverted from the solid waste stream after consumer use. If this term is not noted, or if the package indicates a total recycled content with a percentage of postconsumer content (e.g., 100 percent recycled, 10 percent postconsumer), the rest of the material probably came from excess material generated during normal manufacturing processes. These materials were not used by a consumer or collected through a local recycling program.
- **Recyclable products** can be collected, separated, or otherwise recovered from the solid waste stream for use in the form of raw materials in the manufacture of a new product. This includes products that can be reused, reconditioned, or remanufactured. These products do not necessarily contain recycled materials and only benefit the environment if people recycle them after use. Not all communities collect all types of products for recycling, so it is really only recyclable if your community accepts it.
- **Products wrapped in recycled or recyclable packaging** do not necessarily contain recycled content. They can be wrapped in paper or plastic made from recycled materials, which is a good start, but the most environmentally preferable packaging is none at all.

Consumers must remember to read further than the recycling symbol or the vague language to find specific and verifiable claims. When in doubt about the recycled content of an item, contact the manufacturer for information; this will also raise the company's awareness of shoppers' interest in environmentally preferable products.

Buy-Recycled Facts

- Aluminum cans contain an average of 50 percent recycled postconsumer content, while glass bottles contain an average of 30 percent.
- How many recycled plastic soda bottles does it take to make...?
  1 XL T-shirt.....5 bottles
  1 Ski jacket filler.....5 bottles
  1 Sweater .....27 bottles
  1 Sleeping bag ....35 bottles
- Manufacturers in the United States bought $5 billion worth of recycled materials in 1995.
- One 6-foot-long plastic park bench can be made from about 1,000 plastic milk jugs.

(Sources: Aluminum Association, 2000; Glass Packaging Institute; Recyclers' Handbook by Earthworks Group, 1997; Anchorage Recycling Center, 2000; American Plastics Council, 1999; National Recycling Coalition)

What Are the Benefits of Buying Recycled?

Important advantages to buying recycled content products include:

- **Waste and Pollution Prevention:** Manufacturing products with recycled-content generally creates less waste and pollution, ranging from truck emissions to raw material scraps.
- **Resource and Energy Conservation:** Making a new product from recycled-content materials generally reduces the amount of energy and virgin materials needed to manufacture the product.

- Economic Development: The Institute for Local Self-Reliance in Washington, DC, estimates that nine jobs are created for every 15,000 tons of solid waste recycled into a new product. These jobs range from low- to high-skilled positions, including materials sorters, dispatchers, truck drivers, brokers, sales representatives, process engineers, and chemists.
- Money Savings: Products such as re-refined motor oil, retreaded tires, and remanufactured automotive batteries will often cost less than their virgin material counterparts.

What Are Some Emerging Trends?

A wider variety of recycled-content products are being produced every day. Some newly available items include electronic equipment, such as computers and printers, made from recycled parts; tape measures made from reconditioned and recycled parts; kitty litter made from recycled drywall; recycled-content plastic office products; and innovative clothing and accessories made from recycled tire inner tubes.

Buying Recycled in Action

Consumers hold the power in their wallets and on their shopping lists. Whether buying items for home, school, or work, consumers must think about the environment and the future as they consider products and brands. Below are activities that will help promote buying recycled:

- Buying recycled-content products personally and encouraging the use of recycled products at school.
- Teaching children about "closing the recycling loop" by organizing a tour of a local facility that manufactures recycled-content products, such as steel products.
- Organizing an exhibit of recycled-content products.
- Asking local stores to stock more recycled-content products that you or the children can use in the classroom.

Buying "Green"

In addition to buying recycled products, consumers can help protect the environment by buying "green": Green shopping can mean:

- Not buying things you don't need
- Buying energy-efficient products
- Buying used or reusable products
- Buying products that have no packaging or reduced packaging
- Buying recycled products or recyclable products
- Buying durable products that will last a long time

Additional Information Resources:

Visit the following Web sites for more information on buying recycled products and solid waste:

- U.S. Environmental Protection Agency (EPA): <www.epa.gov>
- U.S. EPA, Office of Solid Waste site on buying recycled: <www.epa.gov/epaoswer/non-hw/muncpl/buyrec.htm>
- King County, Washington Environmental Links: <www.metrokc.gov/environ.htm>
- Green Seal: <www.GreenSeal.org>
- The American Plastics Council: <www.plasticsresource.com>
- The Official Recycled Products Guide: <www.dep.state.pa.us/wm_apps/recycledproducts>
- The Global Recycling Network: <www.grn.com>
- Buy Recycled Business Alliance: <www.nrc-recycle.org/brba/index.htm>

To order the following additional documents on buying recycled and "green" shopping, call EPA toll-free at (800) 490-9198 or look on the EPA Web site <www.epa.gov/epaoswer/osw/publicat.htm>

- *The Consumer's Handbook for Reducing Solid Waste* (EPA530-K-96-003)
- *A Collection of Solid Waste Resources* on CD-ROM
- *Let's Go Green Shopping* (EPA530-K-04-003)

EPA's WasteWise Program helpline (800 EPA-WISE) has additional resources available. These resources include information on the following:

- State Buy-Recycled Contacts
- *Buy Recycled Guidebook*

social studies

Recycling Rangers

Objective

To help children recognize the similarities and differences among common recyclable items.

Activity Description

Students play a sorting game and put different recyclables into the appropriate bin.

Materials Needed

- Four recycling bins
- Recyclable materials listed in the box below

Key Vocabulary Words

Paper
Plastic
Glass
Metals

Duration

1 hour

Skills Used

Communication
Observation/classification

Activity

Step 1: Set up the four bins in the classroom and label them "Paper," "Glass," "Plastic," and "Metals." Make a pile of all of the recyclable items on the floor and ask the students to gather around them in a circle.

Step 2: Explain to students that by the end of the lesson they will become "Recycling Rangers" and learn how to recycle different items. Discuss with the students how different "garbage" items can be recycled into new products. Note that it is important to separate these items into different categories before they are used to make new products. Refer to the Teacher Fact Sheet titled *Recycling* on page 101 for background information on the recycling process.

Step 3: Ask the students to look at the different recyclable materials and discuss how they are alike and how they are different. Ask them

Recyclable Materials

- — Cardboard
- — Newspapers
- — Magazines
- — Plastic soda bottles
- — Plastic milk containers
- — Glass jars or bottles
- — Aluminum cans
- — Steel food cans
- — Other materials recycled in your community

Note: All materials should be cleaned and all sharp lids or edges should be removed or taped over to avoid injury.

to compare the colors, textures, and weight of the different objects. When handling the glass bottles, take great care not to accidentally break the containers. Also, note that some metal containers have sharp edges that can cause injury to the children.

Step 4: Moving through the pile one item at a time, ask the students to identify the material that each item is made from. Then, choose a student volunteer to place the item in the appropriate bin. For the older children, ask the student volunteer to also name another product that is made from that same material. If a student, for example, is holding a glass jelly jar, he or she could note that soda bottles are also made of glass.

Step 5: After the lesson is concluded, encourage students to go home that night and share what they learned with their parents.

1. Ask students to name some examples of recyclable items.
2. Have students explain why it is important to sort the different recyclable items.
3. Ask students what kinds of materials recyclable items are made from.

1. Select a few objects from the lesson, ensuring a good mix of shapes and sizes. Ask the children to trace outlines of the objects and then color them in. Put the pictures up on the classroom wall to create a recycling art gallery.
2. Organize the class into teams of four children and give each group a different recyclable item. Ask the students to make a new object from the recycled items such as a crayon holder or paper plane.

art

Follow That Bottle!

Objective

To show students the various steps involved in recycling.

Activity Description

While coloring, students will follow the path of the bottle in the *Follow That Bottle!* worksheet.

Materials Needed

- Copies of the *Follow That Bottle!* worksheet for each member of the class
- Crayons

Key Vocabulary Words

Recycling
Processing
Manufacturing
Factory

Duration

1 hour

Skills Used

Motor skills

Activity

Step 1: Using the storyline in the *Follow That Bottle!* worksheet, discuss the life of a recyclable item, such as a plastic bottle, after it is placed in the recycling bin. Explain that items such as bottles, cans, and newspapers can be made into a new product—either the same kind of product or a completely different product—if they are recycled and not thrown away. (Refer to the Teacher Fact Sheet titled *Recycling* on page 101 for background information.)

Step 2: Read and then distribute the *Follow That Bottle!* worksheet and instruct the students to follow the bottle by coloring it with crayons as it is used, recycled, remanufactured, and made into a new product. As the students color, ask them what they think is happening in each section of the picture. Ask them, for example, if anyone has been to a factory or if they recycle at home.

Step 3: After talking about the life of the bottle, students can color the rest of the story board.

Assessment

1. Have students explain what happens to a plastic bottle, or other recyclable, after it is placed in a recycling bin.
2. Ask students to describe their own recycling experiences. Do they use a bin?

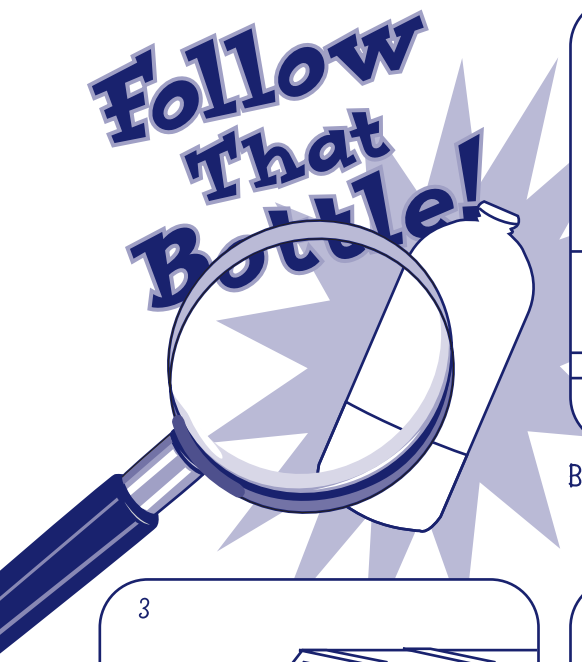
Enrichment

1. Instruct the students to draw a picture of themselves as they recycle common products.
2. Have students sort and separate recyclables from lunch for one week to get a sense of the items that can be recycled in your community. Prepare separate bins for each recyclable.
3. Ask students what happens to the plastic bottle if it does not go in the recycling bin.

Student Handout

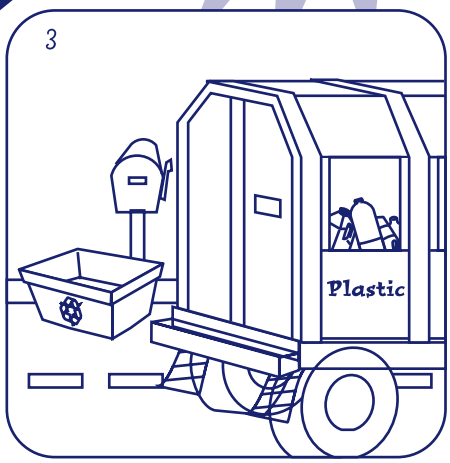
Name: _____

Follow That Bottle!

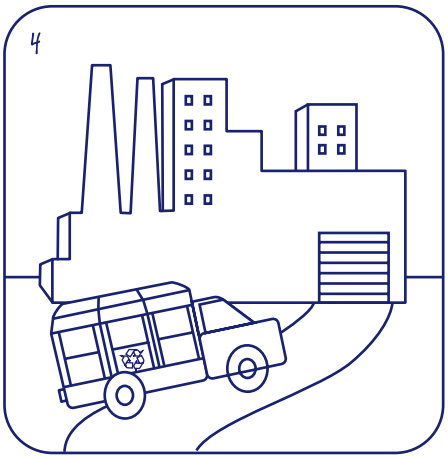


Billy drinks a soda.

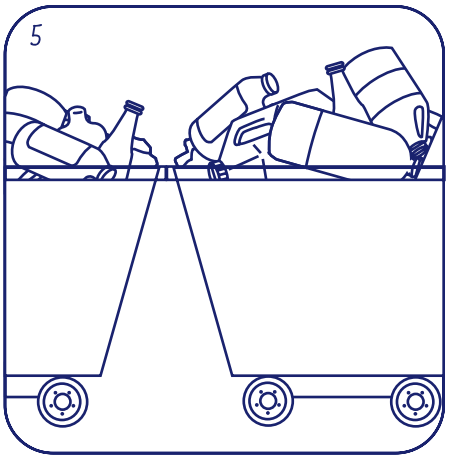
When he is finished, he puts the empty bottle in the recycling bin.



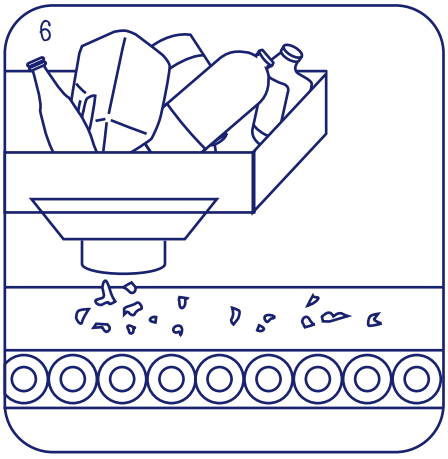
A truck comes to pick up the recycled bottles.



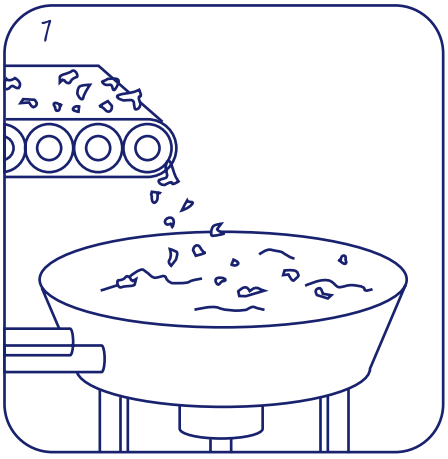
The truck takes the recycled bottles to a factory.



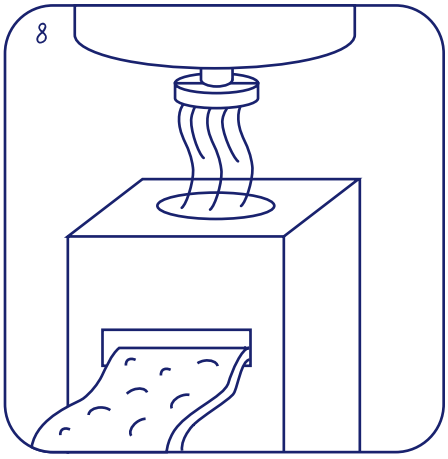
The bottles get separated by color.



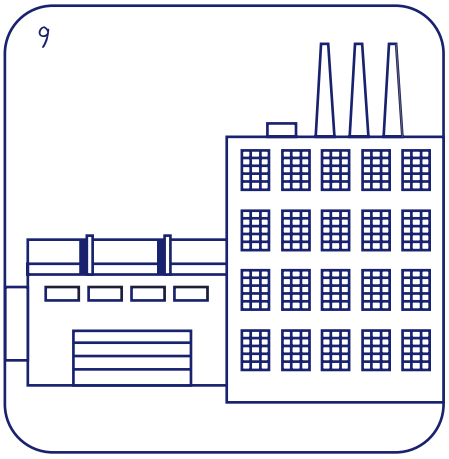
The bottles are ground up into little pieces.



The little plastic pieces are melted...



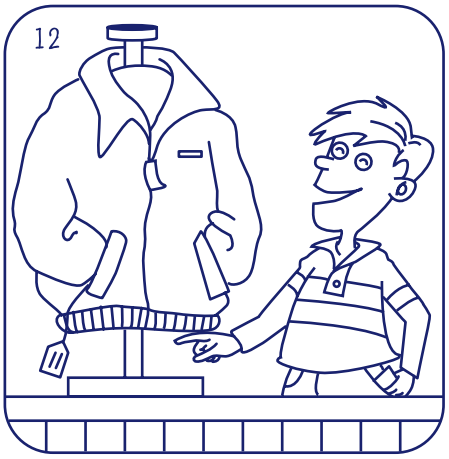
...and made into pieces of thread.



In another factory...

...the plastic thread is used to make clothing.

Jackets, scarves, gloves, and blankets can be made from recycled soda bottles...



...and are sold in stores.

Billy's favorite jacket is made from the soda bottles he recycled!

language arts

art

Take-Home Recycling Kit

Suggestion for Teachers: You might want to find out what materials are collected for recycling in your community before beginning this activity.

Objective

To teach students the value of recycling and encourage them to discuss recycling with their families.

Activity Description

Students will assemble a take-home recycling kit.

Materials Needed

- *Recycling Facts* handout for each member of the class
- Old magazines and newspapers
- Used cardboard
- Construction paper
- Markers and/or paint
- Glue
- Scissors
- Any other arts and crafts supplies available

Key Vocabulary Words

Recycling
Processing

Duration

2 hours

Skills Used

Communication
Motor skills

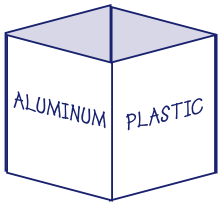
Activity

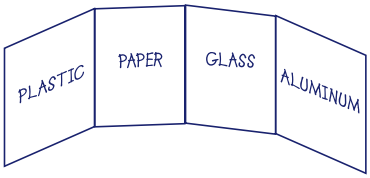
Step 1: Explain how recycling works and the important role we all can play by recycling items instead of throwing them away. (Refer to the Teacher Fact Sheet titled *Recycling* on page 101 for more information.) Review the information on the following *Recycling Facts* handouts with the students, pointing out the economic and environmental benefits of recycling.

Step 2: Have each student cut the old cardboard boxes into four 8 ½- by 11-inch pieces and glue different colored sheets of construction paper to each side of the cardboard.

Connect each piece of cardboard with tape to form a placard that can stand on a table. Instruct the students to label each cardboard piece with one of the following recyclables: aluminum, glass, plastic, and paper (see examples below).

Step 3: Instruct the class to cut out or draw the appropriate recyclable for each cardboard





Journal Activity

Ask students to interview their family members about recycling practices and views on recycling. Ask students to write a short article on their families' current views and how their recycling kit changed those views or practices.

placard using the magazines, newspapers, markers, and paints. Ask students to write information about recycling on each placard. Optional recycling facts are included on the attached handout and might assist students in this task.

Step 4: When the students are finished decorating their placards, ask them to take them home and affix them where their family keeps its recyclables or its trash to encourage families that don't already recycle to start. Ask students to share the information they learned about recycling with their parents. Explain how the placards serve as friendly reminders of the importance and benefits of recycling.

Assessment

1. Ask students to list the ways recycling helps the environment and why these benefits are important.
2. Ask students what role each of us can play in recycling.

Enrichment

1. If your community recycles, but the majority of the class' families do not recycle at home, have the students practice a "recycling pitch" to their parents using their placards and other facts about the benefits of recycling. Also, students could develop a commercial using their placards and draw a story board of it or create a skit that is then videotaped.
2. Make signs for the classroom or school recycling bin. Ask students to put cans, bottles, or other items from their lunches in the recycling bins in the classroom or school. When the bins are full, take them to a collection facility and use the money to buy treats for the class.
3. Organize a tour of a recyclables processing facility or a manufacturing plant that uses recycled materials.

Recycling Facts

Paper

- The average amount of recycled fiber in newspapers increased from 10 percent in the late 1980s to more than 30 percent today.

- By recycling or reusing 1 ton of paper, we save 17 trees, 7,000 gallons of water, 463 gallons of oil, 3 cubic yards of landfill space, and enough energy to heat an average home for 6 months.
- Americans recycled 36.7 million tons of paper and paperboard in 2001.

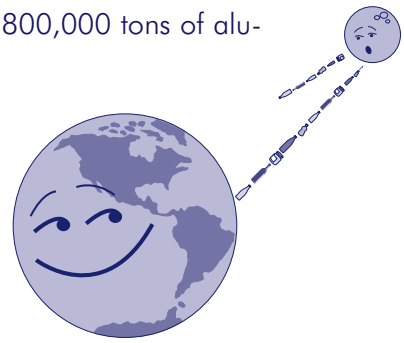
Plastic

- Using fewer than five recycled plastic soda bottles, manufacturers can make one extra-large T-shirt.
- Milk jugs can be made into all different types of plastic objects, from park benches to boardwalks.
- Recycled plastic soda bottles can be made into "fleece" sweaters, long underwear, stuffing for sleeping bags, and other items.

- Americans recycled 1.4 million tons of plastics in 2001.

Aluminum

- Recycling aluminum cans saves 95 percent of the energy required to make aluminum cans from scratch.
- Americans earn about $1 billion from recycling aluminum cans each year.
- Every minute, an average of 127,093 aluminum beverage cans are recycled in the United States.
- The amount of aluminum recycled in 2001 could have built 14 aircraft carriers.
- American's recycled 800,000 tons of aluminum in 2001.



Glass

- If all the glass bottles and jars recycled were laid end-to-end, they would reach the moon and make it more than halfway back to Earth.
- Most bottles and jars contain at least 25 percent recycled glass.
- Every ton of new glass produced results in 27.8 pounds of air pollution, but recycling glass reduces that pollution by 14 to 20 percent.
- American's recycled 2.4 million tons of glass in 2001.

Sources: EPA, 2003; American Forest and Paper Association; Can Manufacturers Institute; www.green-networld.com/tips/glass.htm.

Making Glass From Scratch

Objective

To teach students about the processes and resources used in the manufacture of glass and to introduce how recycling glass is good for the environment.

Activity Description

Students make a glass-like substance using sugar and water.

Materials Needed

- 1 cup sugar
- 1/4 cup water
- Hot plate and sauce pan or hot pot (to boil water)
- 8-inch square sheet of glass or a cookie sheet
- Newspaper
- Assorted glass objects

Key Vocabulary Words

Glass
Heat
Energy
Natural resources
Reuse
Recycle
Resource
Minerals
Raw materials

Duration

45 minutes

Skills Used

Communication
Reading
Observation/classification
Problem solving

Activity

Step 1: Discuss how glass is made (i.e., that sand, soda and lime are heated together at high temperatures), emphasizing the heat and energy required during the manufacturing process. Explain to students that glass containers can be remelted or "recycled" to make new glass containers, saving valuable resources in the process. (Refer to the Teacher Fact Sheets titled *Products* on page 25 and *Recycling* on page 101 for background on the manufacturing process.) During the discussion, allow students to touch a variety of different glass objects (e.g., beverage container, jelly jar, vase). Ask them to describe the colors, shapes, and textures of the different items.

Step 2: Begin the glassmaking exercise by heating the water. Tell students you are going to make "pretend" glass using sugar in place of the actual raw material, sand. Let students examine the sugar and describe it in terms of its color, texture, and shape. Point out the similarities between the sugar and sand. Have students describe the water and how it changes as the heat begins to make the water boil (e.g., after the sugar has melted it will look like a brown liquid). Point out the heat energy involved in making the water boil as well as the steam that is produced. Next, pour the sugar into the boiling water. Tell students to pretend the sugar is sand (minerals) from the ground.

Step 3: Stir the mixture vigorously over the heat until the sugar is dissolved (about 5 minutes). Ask students to describe the changes in the sugar and water. Tell them this is how glass looks before it cools.

Step 4: Put several layers of newspaper under a sheet of glass or a cookie sheet. (If you are worried about handling glass, use a cookie sheet—although students will not be able to see through it.) Carefully pour the mixture onto the sheet of glass and allow it to cool (about 15 minutes).

Step 5: Hold up the sheet of "glass" so students can see through it. By allowing it to set overnight, the "glass" will become frosted. The next day, ask students to describe the changes that occurred overnight and why (e.g., the water evaporated leaving sugar crystals behind).

Step 6: As an optional exercise, illustrate glass recycling by scraping the dried "glass" back into the pan (pretending it is small pieces of crushed, recycled glass), adding water, and reboiling the mixture. More sugar will need to be added to repeat the procedure. Ask students which resources were replaced when the crushed glass was used to make the new glass (minerals, energy).

1. Ask students what materials are used to make virgin (nonrecycled) and recycled glass bottles. Older students may illustrate the process, labeling the natural resources used to make glass and show which ones are replaced when recycled glass is used as a raw material.
2. Have students describe how recycling glass is good for the environment.

1. Perform a molding glass exercise. For this project, you will need one wide-mouth glass jar per group of four to six students, and one stiff straw or glass tubing, balloon, and rubber band per student. To begin, divide the class into small groups of four to six students and give each group a wide-mouth jar. Next, give each student a straw or glass tubing, balloon, and rubber band. Assist students in attaching the balloon to the straw with the rubber band. Ask students to take turns putting the balloon into the jar and blowing it up until it takes the shape of the jar. Explain that this process illustrates how glass is molded into a jar or other shape during the manufacture of glass containers.
2. Bring samples of handmade glass to class and show students the bubbles in the glass formed by a person blowing air into the hot glass mixture. Point out the irregularities that identify the glass as handmade. Visit a glass blower, if possible. These individuals often participate in local crafts festivals or similar events.
3. Ask students to look around their homes for glass products that could be recycled to make new glass. Ask students to make a list of the items and bring the list to class. Have students share their lists and then discuss which items can and cannot be used for recycling (for example, items not commonly accepted for recycling are lightbulbs, mirrors, windows, etc.).

science

art

Handmade Recycled Paper Planters

Objective

To show students how easy it can be to make products from recycled items.

Activity Description

Students will make planters from recycled paper.

Materials Needed

- Large stack of newspapers
- Scissors
- Three to five 2-gallon buckets
- Water
- Egg beaters
- Magnifying glass
- Plant seeds for each student
- Planting soil
- Paper drinking cups

Key Vocabulary Words

Recycle
Fibers
Decompose
Pulp
Virgin materials
Resources

Duration

2-3 hours

Skills Used

Motor skills

Note: Try to reuse a cup-shaped container instead of using paper drinking cups. For example, you could use reusable plastic drinking cups, plastic planter molds, or milk containers.

Activity

Step 1: Introduce the concepts of recycling and decomposition to the class. Explain that making items from recyclables rather than virgin materials benefits the environment by saving natural resources. (Refer to the Teacher Fact Sheets titled *Recycling* on page 101 and *Natural Resources* on page 5 for background information. The *Composting* fact sheet on page 141 contains information on decomposition.)

Step 2: Discuss with the class how paper is made. Explain that most paper is made from only trees, while other paper is made from a combination of trees and old newspaper or used office paper (in addition, a small percentage of paper is made from other fibrous materials such as cotton, papyrus, or rags). Discuss how when recycled paper is used to make new paper, less trees need to be cut down. Help students explore the environmental implications of this.

Step 2: Have each student cut up two full pages of newspaper into ½- to 1-inch square pieces.

Step 3: Ask a few student volunteers to fill the buckets 1/3 full with paper and the remaining 2/3 with water (1 part paper to 2 parts water).

Journal Activity

Ask students to write a story about their seedling's journey from its first days in the planter to when it takes root in the ground outdoors.

Step 4: Let the mixture sit overnight. By the next day, the newspaper fibers will be soft and ready to pulp.

Step 5: On the second day, have students take turns pulping the fibers with the hand beater until the paper and water look like mush. Explain that the pulping process breaks down the fibers into a form that can be bonded together again to make recycled paper. Have students look at the pulp with a magnifying glass to see the loose wood fibers.

Step 6: Give each student a plastic cup-shaped container. Instruct them to mold the pulp to the inside of the cup, squeezing out as much of the water as possible. The pulp should be 1/4- to 1/2-inch thick on the inside of the cup.

Step 7: Let the pulp dry completely over the next 3 days.

Step 8: After the pulp has dried, take the handmade recycled paper cup out of the drinking cup.

Step 9: Give each student a seed and instruct them to plant it in the cup using the planting soil. Keep the planters in the classroom and have the students care for the plants. Discuss how much sunlight and water their plants need.

Step 10: Send the students home with their planters when the seedlings have sprouted and are ready to be planted in the ground. Instruct the students to place the whole cup with the plant in it into the ground.

Students in an urban setting could either plant their seedlings in a local park or decorate their planters and donate the seedlings to a local nursing home. (Students also could give a presentation on recycling to the elderly when they drop off their planters.)

Step 11: Discuss how the planter will decompose in the soil and the plant will take root in the ground. Explain that they have just completed the recycling loop by sending the nutrients from the paper cup back into the soil.

Assessment

1. Ask students where paper comes from.
2. Ask students to explain how making paper from used paper benefits the environment.
3. Ask students how and why the planter will decompose in the ground.

Enrichment

1. On the blackboard or as a handout, work with the students to diagram and label all of the steps that occur in making paper from recycled materials versus making paper from only virgin materials. Discuss the differences.
2. Instead of sending the students home with the seedlings, start a garden at the school and tend it regularly with the class.
3. Have students discuss what else they can do to reduce the number of trees being cut down to make paper.

Recycling...Sorting It All Out

math

science

Objective

To help students test and better understand the properties of different recyclable materials.

Activity Description

Students rotate to different stations to evaluate recyclable items and learn how to sort them into different categories.

Materials Needed

- Recyclable items listed below
- Magnets
- An aquarium tank or other large container filled with water
- Rocks or other items that vary in density
- Balance scale
- Scissors
- Tablespoon of sand
- Copies of the *Sorting Statistics Worksheet*
- Calculators (optional)

Key Vocabulary Words

Sorting
Recyclables
Magnetism
Density
Mass
Matter

Duration

1 hour

Skills Used

Communication
Research
Computation
Observation/classification

Activity

Step 1: A day or two before the lesson, ask students to bring in different recyclable items from home or collect items left over from lunch. See the box at right for the list of materials to request. Be sure to clean these items before the lesson and remove any sharp edges. Store these items in a utility closet or some other storage room at the school until you are ready to conduct the lesson.

Step 2: To begin the lesson, discuss how waste is reduced by recycling. Explain how after recyclables are collected from businesses and homes, they are sent to a facility where they are sorted into different categories of materials. Explain that it is important for recyclers to tell the difference between materials because they end up being recycled into different products. (Refer to the Teacher Fact Sheet titled *Recycling* on page 101 for more information on this process).

Journal Activity

Ask students if they can think of an innovative way to sort recyclables? Ask them to describe or draw their invention.

Step 3: Organize three different stations throughout the classroom.

Station One should include the steel and aluminum cans, a magnet, and an information sheet about magnetism. This sheet should explain that magnets are pieces of iron or steel that can attract other metals.

Station Two should include the plastic items and a large container (e.g., an aquarium) filled with water, along with scissors and a few heavy and light objects. You should prepare an information sheet explaining that density refers to how compact an object is. As an example, note that a bowling ball is much more dense than a foam rubber ball of the same size because the bowling ball is more compact and made of heavier material.

Station Three should include the paper items and a scale. An information sheet should explain that mass refers to the amount of matter in an object. You can weigh an object on a scale to determine its mass.

Step 4: Once the stations are set up, hand out worksheets, break the students up into groups of three, and explain that students should rotate from station to station in their groups and fill out their worksheet as they go. Students can discuss answers within their groups.

Step 5: At Station One, have students experiment with the magnet and the different cans to discover that some of the cans are attracted to the magnet while others are not. At Station Two, students should compare the density of various plastic items. Students can compare the density of other items with plastic, and can cut up plastic into pieces to see how density is affected. At Station Three, students can place various paper items on the scale and record the different weights.

Step 6: Discuss the questions from the worksheet. Students should understand that recycling sorting facilities use magnets to separate the steel cans from the rest of the collected recyclables. They should also understand that density is important because it can be used to identify and separate different items. Recycling sorting facilities use sinking/floating exercises to sort plastics from other materials, such as crushed glass, since plastic containers float. Students should also understand that sorting facilities use scales to weigh the recyclable materials they receive so they know how much material is being recycled.

Assessment

1. Ask students to explain magnetism. Ask them why only some objects are attracted to magnets. Which ones?
2. Ask students to explain density and how to test for it.
3. Ask students what mass means. Have them explain how to test something to determine its mass.
4. Have students list some of the techniques that sorting facilities use to separate different recyclables.

Enrichment

1. Visit a local recycling materials recovery facility to see firsthand how the different recyclables are sorted.
2. Ask students to draw their own recycling sorting facility. Ask them to start with a pile of recyclables at one end and show how the different recyclables would be separated (e.g., magnets, conveyor belts) as they move through the facility. Ask them to decide whether their diagram will only involve machinery or whether it will involve people to sort some of the items. Ask them to label each of the different stations in the facility and describe how each station works.

Sorting Statistics

Name:

_____

Station One

1. How many steel cans are at Station One? Use the magnet to find out. Now, multiply that number by the number of students in your classroom. If you recycled 56 percent of these cans, approximately how many would that be? As a nation, we recycled 56 percent of our steel cans in 1998.

_____

_____

2. How would magnets help workers at a recycling sorting facility?

_____

_____

3. Suppose you have 10 aluminum cans—5 containing recycled aluminum and 5 with no recycled content (made from bauxite, the primary ore). Next, suppose it takes 5 watts of energy to make a can with recycled aluminum and 100 watts to make a can from bauxite. How much energy does it take to make the 5 recycled-content cans? How about the 5 nonrecycled cans? Note that it takes 95 percent less energy to make an aluminum can from recycled aluminum versus making one from scratch.

_____

_____

4. Calculate the aluminum can recycling rate for Anywhereville, USA, given the following information:

- 1,938 pounds of aluminum cans were recycled
- 3,370 pounds of aluminum cans were produced
- There are an average of 33.04 cans per pound

Number of cans recycled:

_____

Number of cans produced:

_____

Recycling rate:

_____

Station Two

1. Does the size and shape of an object affect its density? Test a few different types of plastic objects in the water and record your results. You can cut up some plastic and try some other objects for comparison—record all results.

_____

_____

2. How is testing for density helpful to a recycling sorting facility?

_____

_____

3. Note that the following formula is used to determine the density of an item: density = mass (grams)/volume (centimeters^3). Now, assume a piece of garbage—a popcorn bag—has a mass of 12 grams and a volume of 5 centimeters^3. What is its density?

_____

_____

4. Note that water has a density of 1.0 g/cm^3. Items that have a density of less than 1 float in water, while those that are more than 1 sink. Do plastic bottles have a density greater or less than 1?

_____

_____

Station Three

1. Describe the characteristics of the different types of paper. How are they similar? How are they different? Consider color, texture, glossiness, thickness, etc.

_____

_____

2. Assuming you recycle 7 newspapers a week, 365 days a year, how many newspapers do you recycle per year?

_____

_____

3. Using the scale at Station Three, weigh a newspaper to determine its mass. Using your answer from question 2, what is the total mass (in pounds) of the newspapers you recycle each year? In tons? (There are 2,205 pounds in a ton.)

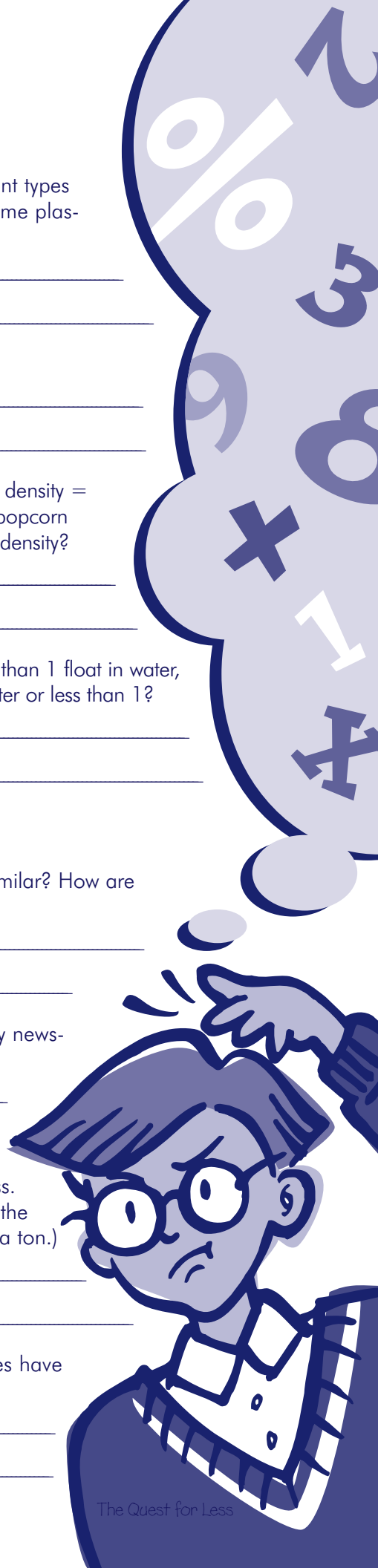
_____

_____

4. Assuming that each ton of paper recycled saves 17 trees, how many trees have you saved by recycling your newspaper each year?

_____

_____



Designing the Ultimate Can Crusher

Objective

To help students understand simple machines and manipulate materials and tools to build their own machine.

Activity Description

Students work in teams to design and construct a machine to crush aluminum cans. Students then vote for the best design.

Materials Needed

- Construction items listed in the box below
- Hammer
- Saw
- Screwdriver
- Pliers
- Wire cutters
- Ruler and/or measuring tape

Key Vocabulary Words

Recycling
Recyclables
Compaction

Duration

Set-up/design: 1 hour
Construction: 1 to 2 hours

Skills Used

Research
Computation
Motor skills

Activity

Step 1: Several days before the lesson, ask students to bring in different construction items from the list to the right. Be sure to store these items in a safe place at the school where students cannot access them and hurt themselves. Also, note that this lesson will work best in a shop room or similar area with plenty of open space and room for students to work.

Step 2: To begin the lesson, introduce the concept of simple machines—levers, pulleys, etc. Next, explain how simple machines are used in the recycling process. Recycling facilities use machines, for example, to crush aluminum cans

Construction Items

Aluminum cans
Rope
Wire
Hinges
Screws
Nails
Wood scraps
Bricks
Blocks
Other construction items

Journal Activity

Ask students to describe the most challenging part of designing their can crusher. Ask them how they overcame this challenge.

to make them easier to store and ship since they require less space when crushed (Refer to the Teacher Fact Sheet titled *Recycling* on page 101 for more information on this process).

Step 3: Divide the class into small groups of four or five students.

Step 4: Place a few aluminum cans on the floor. Ask a volunteer to crush the cans with his or her foot. Have students identify what is involved in crushing a can. Ask them to describe what happens to the can.

Step 5: Have students examine all of the construction materials brought to class. Explain that the job of each group is to use these materials to design and construct a can crushing machine. Each group should use at least one "simple machine" in their construction.

Step 6: Tell students that they should begin the project with a design phase. You may want to spend several class periods on this stage. Ask students to work together to draw a diagram for how their can crusher would work. Have them make a list of all of the items they will need for their machine. Make sure these items are already in the classroom or can be brought from home. Ask students to write instructions for how they will build their can crusher. Encourage them to take measurements and be as detailed as possible.

Step 7: Review each group's designs carefully to ensure they are reasonable given the materials required and time frame of the assignment. Ask each group to explain to you how their machine will work.

Step 8: Conduct a safety lesson regarding the appropriate use of the tools. Ask students to use caution and remember that the tools are not toys.

Step 9: Under close adult supervision (you might need adult volunteers to help), ask students to begin the construction phase. It may take several class periods for students to complete their can crushers. Have students follow their directions carefully and encourage them to ask questions throughout the process.

Step 10: Once all of the machines are constructed, tell students that it is time to test them. Ask each group of students to demonstrate to the class how their can crusher works. Allow other students to ask questions.

Assessment

1. Ask students to explain why it is important for recycling facilities to crush the aluminum cans.
2. Ask students why it is important to develop a detailed design first rather than immediately building a machine.
3. Have students explain why it is important to test the machine.
4. Have students explain how the machine makes crushing cans easier than doing it by hand.

Enrichment

After everyone has demonstrated their crushers, have each student rank each project on a scale of 1 to 10 for each of several categories, such as: total cost of materials, ease of use, efficiency, size, safety, effectiveness, time to construct, etc.

1. Organize a recycling drive for aluminum cans at your school. The can crusher contest can be used to draw attention to the drive. The can crushers designed by the students can be used to help store the cans more easily before they are taken to a recycling center.
2. Invite a local recycling coordinator or recycling professional to your class to talk with students about what he or she does. Ask the visitor to bring in pictures of baled, crushed recyclables as well as samples of recycled products, if possible.

Learn to Recycle

Art

Language Arts

Objective

To teach students the specifics of recycling in their community or help them understand why their community does not recycle.

Activity Description

Students will research local recycling options, including where to recycle, what can be recycled, and how to prepare recyclables.

Materials Needed

- Supplies for presentation (will differ depending on format)
- Phone
- Computer with Internet access

Key Vocabulary Words

Materials Recovery Facility (MRF)
Processing
Recyclables
Recycling

Duration

Day 1: 1 hour+
Day 2: 1 hour

Skills Used

Communications
Research

Activity

Step 1: Explain to students that local governments and private companies usually manage solid waste and recycling. It is important that they understand what can be recycled to ensure proper recycling processes. (Refer to the Teacher Fact Sheet titled *Recycling* on page 101.)

Step 2: Assign specific research tasks to different groups of students. One group should make calls, search the Internet, or visit the local library to find out where to recycle locally (e.g., curbside service, drop-off locations). Another group should find out what items can be recycled and how to prepare those items for recycling (e.g., rinse plastic bottles and remove lids). Another group can discover how, when, and where to recycle nonstandard items (e.g., paint, electronics, packing peanuts, motor oil, batteries, hangers, fluorescent light bulbs, scrap tires).

Research can be conducted in the classroom, after school, or at home.

If students speak to a recycling official, have them inquire about recycling collection methods. Are the items separated by type or mixed together and sorted later? How does collection at businesses differ from household collection or collection at apartment buildings?

Students may also inquire about where their recyclables are sent after they are collected. What types of products are made from their recyclables? How are the materials processed to create other products?

Step 3: Each group should work together to present their findings. The presentations can be verbal, computer-based, artistic, etc. Presentations could be aimed at persuading a neighbor, family member, another student, or others, to recycle.

1. Using the research already collected, or by doing additional research, have the students take a closer look at recyclables. Visit trade association and other Web sites to find out three facts for specific commodities (e.g., aluminum, glass bottles, paper, plastics, steel cans). What do the numbers imprinted on plastic containers mean? What percent of recycled steel is used to make a new steel can? How long does it take for aluminum cans to be recycled? Sample sites include <www.epa.gov/msw/reduce.htm>, <www.cancentral.com>, <www.afandpa.org>, <www.plastics.org>, <www.recycle-steel.org>, <www.gpi.org>, and <www.epa.gov/epaoswer/non-hw/muncpl/faq.htm#11>. List the facts in the worksheet and use it as the basis for a class discussion.
2. Use the information gathered to create a brochure, fact sheet, or video explaining "How to Recycle" in your community. Make copies for students of all grade levels to share with their parents or hand out at community events/locations (e.g., local library, township administration building). Coordinate with your local recycling officials to see samples of similar publications they may have produced or to have them check the accuracy of the information you are providing.
3. Start a school recycling club that students can join to learn about recycling and to serve as the recycling watchdog at school and within the community.
4. Let students see first hand what happens to trash and recyclables by taking a field trip to the local landfill and recycling center.

Recycling: Just the Facts

Name: _____

Assignment:

Research Sources:

Facts Learned:

science

math

Recycling Includes E-Cycling

Objective

To introduce students to electronics recycling.

Activity Description

Assess different types of household electronics, their lifespan, and opportunities for recycling them.

Materials Needed

- Worksheet: Electronics Inventory
- *Life Cycle of a Cell Phone* Poster (to order a free poster, call EPA at (800) 490-9198 and reference document number EPA530-H-04-002)

Key Vocabulary Words

Recycle
Demanufacture
Life cycle
Remanufacture

Duration

Two classroom periods

Skills Used

Observation/classification
Communication

Activity

Step 1: Provide students with an overview of the life cycle of electronics. The "life cycle" includes all aspects of the life of the electronics—from mining raw materials to manufacturing to disposal or recycling. Use the information below as well as the *Life Cycle of a Cell Phone* poster as sources of information for this discussion. Students can complete the activities on the poster as part of the classroom activity. You can also consult the Web site <www.plugintoecycling.org> for more background information.

Ask students to think of ways they can conserve the precious resources locked inside used electronics and how they can prevent pollution from disposal. Have them create a personal "to do" list addressing these issues.

Electronics are made from many different resources, including plastic (made from petroleum) and various metals (mined from the earth). That's why recycling electronics is so important—to recover these materials to use again. Recycling electronics requires demanufacturing, or dismantling, them, which is labor-intensive, but it yields valuable resources that can be used to make new electronics or other products. In 1998, more than 112 million pounds of materials were recovered from electronics including steel, glass, plastic, and precious metals.

Electronics (especially computers) become outdated very quickly and need to be replaced often. In fact, nearly 250 million computers will become obsolete in the next 5 years. When no longer used, electronics are often thrown away, ending up in landfills and incinerators. Electronics can contain substances that can contaminate the soil and ground water. In fact, TVs and computers can contain an average of 4 pounds of lead (depending on their size, make, and vintage) as well as other potential toxics like cadmium, mercury, beryllium, nickel, zinc, and brominated flame retardants.

Step 2: For homework, ask students to take stock of the electronics in their home using the Electronics Inventory worksheet. They should inventory their entire household, noting all electronics—from computers to DVD players to calculators. They should estimate each item's life span and recyclability (e.g., computers must be replaced every few years, while calculators last longer). In addition, they should also think about where and how each item can be recycled/reused (e.g., donated to charity, sent back to the manufacturer, demanufactured).

If time permits, students may also want to contact electronics companies or use the Internet to find out which companies offer take-back programs for used electronics. Students can ask the companies or search the Web to find out if the products in their homes contain recycled-content materials or are designed for easier recycling.

Students may also want to contact their local government's solid waste office and ask for recommendations about recycling or donating used electronics.

Step 3: Discuss the results of the students' electronics inventories (see Assessment for discussion questions).

Ask students which electronics have the longest life span and why. Is it because of technology changes or better physical design? Do the newer models have more or fewer environmental impacts? How often do people need to buy new models of electronics? What else did students learn from their home inventories? How does what they learned apply to other items in their home?

1. Invite a local recycling official to speak to the class about electronics recycling and/or local electronics recycling events.
2. Take a field trip to an electronics recycling facility.
3. Ask students to think about questions they could ask electronics store employees the next time they are shopping. Do they accept used electronics for recycling? Do they know an organization that accepts them?

Electronics Inventory

Name: _____

CHAPTER 2.3

Composting

Teacher Fact Sheet: Composting 141

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Grade • Subject • Skills Index

Activity Name	Compost Critters	Compost Chefs	Compost Crops	Worms at Work
Grade Range				
K	✔			
1	✔			
2				
3		✔	✔	
4		✔	✔	✔
5		✔	✔	✔
6		✔	✔	✔
7		✔	✔	✔
8		✔	✔	✔
Subjects Covered				
Math			✔	
Science	✔	✔	✔	✔
Language Arts				
Social Studies				
Art				
Health				
Skills Used*				
Communication				
Reading				
Research				
Computation		✔	✔	✔
Observation/ Classification	✔	✔	✔	✔
Problem Solving				
Motor Skills	✔	✔	✔	✔

*See Glossary of Skills for more details.

Composting

What Is Composting?

Composting is the controlled **thermophilic** (130°-150°F) **decomposition** of organic materials such as leaves, grass, and food scraps by various organisms. Composting can be divided into three types: backyard, or home, composting; vermicomposting; and heat-based composting.

Home composting is the natural degradation of yard trimmings, food scraps, wood ashes, shredded paper, coffee grounds, and other household organic waste by naturally occurring microscopic organisms. **Vermicomposting** is the natural degradation of similar household organic waste using naturally occurring microscopic organisms and the digestive process of earthworms. Heat-based composting is performed by municipal or commercial facilities that increase the rate of degradation using high temperatures.

Varying amounts of heat, water, air, and food produce different qualities of compost as a final product. Heat-based compost differs from compost produced at ambient temperatures (e.g., a forest floor or home composting) because high temperatures destroy both weed seeds and pathogens. Composts produced by all three systems are crumbly, earthy-smelling, soil-like materials with a variety of beneficial organisms.

Key Points

- Composting is the controlled decomposition of organic materials.
- There are three methods of composting: home or backyard composting, vermicomposting, and heat-based composting.
- Invertebrates and microorganisms in compost are key to the breakdown of the organic materials into a rich soil-like product.
- Quality compost is the result of the proper mixture of carbon and nitrogen sources and adequate amounts of moisture, oxygen, and time. Certain food items should be avoided when home composting.
- More than 67 percent of the waste produced in the United States (including paper) is compostable material.
- Compost is a valuable product that can be used as a soil amendment, mulch, or even to decontaminate natural habitats, storm water, and brownfields.
- Composting helps divert a large portion of America's organic trash from landfills and combustion facilities.

Worms—A Composter's Best Friend

Vermicomposting is a method of composting using a special kind of earthworm known as a red wiggler (*Elsenia fetida*), which eats its weight in organic matter each day. Vermicomposting is typically done in a covered container with a bedding of dirt, newspaper, or leaves. Food scraps (without added fats) can then be added as food for the worms. Over time, the food will be replaced with worm droppings, a rich brown matter that is an excellent natural plant food. Vermicomposting requires less space than normal composting methods, and is therefore ideal for classrooms, apartments, and those in high-density urban areas.

Composting in Action

An easy way to understand all the factors that go into composting is with a hands-on demonstration. A school can provide the perfect medium for these demonstrations. Classes could start a composting bin using food scraps from the cafeteria and yard trimmings from ground maintenance. Depending on the scope of the project, the compost could then be sold to the community in addition to being used on the school campus. Tour a local composting facility, if composting cannot be done at school. For more information on how to start a school composting project, go to the Cornell University composting Web site at <http://compost.css.cornell.edu/composting_homepage.html> or use these suggested activities to get you started:

- Start a compost pile or bin in the school or as a class experiment.
- Try using compost in place of chemical fertilizers, pesticides, and fungicides. Use compost made by the school or buy it from municipalities or private companies.

The decomposition of organic materials in composting involves both physical and chemical processes. During decomposition, organic materials are broken down through the activities and appetites of bacteria, fungi, and various invertebrates that will naturally appear in compost, such as mites, millipedes, beetles, sowbugs, earwigs, earthworms, slugs, and snails. These microorganisms and insects found in decomposing matter need adequate moisture and oxygen to degrade the organic materials in the most efficient manner.

How Does Composting Work?

Compost contains both carbon and nitrogen sources, which can be simplified as browns (e.g., leaves, straw, woody materials) and greens (e.g., grass and food scraps), respectively. Adequate sources of carbon and nitrogen are important for microorganism growth and energy. The ideal ratio is 30 parts brown to 1 part green. Odor and other problems can occur if the ratio or any of the factors discussed below are not right.

The browns and greens can be mixed together to form compost in a backyard bin or in a municipal compost facility. Whether the composting is done on a small scale or large, the composting process is the same. To encourage decomposition throughout the pile, the compost should be kept moist and turned periodically.

What Are the Benefits of Composting?

As a method of handling the large amount of organic waste created in the United States each day, composting makes good environmental sense. Instead of throwing organic materials away, they can be turned into a useful resource.

In addition, many organic wastes are not ideally suited for disposal in combustion facilities or landfills. Food scraps and yard trimmings tend to make inferior fuel for combustors because of their high moisture content. Decomposition of organic wastes in landfills can create methane, a greenhouse gas that is environmentally harmful because it destroys atmospheric ozone.

Because yard trimmings and food scraps make up about 24 percent of the waste U.S. households generate (EPA, 2003), backyard or home composting can greatly reduce the amount of

waste that ends up in landfills or combustors. In addition, compost is a valuable product that can be used as a soil additive for backyard gardens and farm lands or in highway beautification and other landscape projects.

The benefits don't end there—composting also makes good economic sense. Composting can reduce a community's solid waste transportation, disposal, and processing costs. In many communities, residents pay for each bag or can of trash they put out for pickup. If a household is composting, it will most likely put less in trash cans and will pay a smaller trash bill.

In backyards and on the community level, interest in composting has increased rapidly over the past several years. Yard trimmings programs constitute the large majority of composting operations in the United States. In these programs, community members place their yard trimmings in a separate bag or container at the curb, which is collected and taken to a municipal composting facility. These facilities create large amounts of compost, which, in many cases, is sold back to community members. People can also purchase compost created by private composting companies.

What Are the Challenges Associated With Composting?

Creating quality compost requires the right mix of materials and attention to moisture, particle size, and temperature. Too little moisture will slow the decomposition, but too much can create odor problems. To avoid attracting pests and rodents, composters should monitor the food scraps put in the compost pile. Meat scraps, fats, and oils are difficult items to compost, attract pests, and should be kept away from the compost pile, and thrown away instead.

While composting increases the rate of natural organic decomposition, it still takes months for compost to mature. If compost is used while it is still "cooking," the high temperatures could kill the plant life on which it is spread. In addition, using compost before it is ready can encourage weed growth because the high temperatures of the pile have not had a chance to kill any potential weed seeds.

What Are Some Emerging Trends in Composting?

A large amount of organic waste is created by institutions, restaurants, and grocery stores—perfect for compost. Across the country, many of

What Can Go Into a Composting Bin?

This list is not meant to be all inclusive. Some food products should not be included because they can attract pests or compromise the quality of the compost.

Materials to Include	Materials to Exclude
Fruit and vegetable scraps	Meats
Tea bags	Dairy foods
Wool and cotton rags	Bones
Coffee grounds with filters	Fats
Grass/Yard clippings	Pet excrement
Leaves	Diseased plants
Egg shells	Grease
Sawdust	Oils (including peanut butter and mayonnaise)
Fireplace ash	
Nonrecyclable paper	
Vacuum cleaner lint	
Fish scraps	

these businesses are participating in pilot projects to compost their food scraps and soiled paper products. These businesses can not only provide a valuable component of compost—organic material—but also can reduce their waste disposal costs significantly.

Compost is also being used as an innovative technology to clean up land contaminated by hazardous wastes, remove contaminants from storm water, facilitate reforestation, and restore wetlands and other natural habitats. Compost has been used to restore soil that is contaminated with explosives, munitions wastes, petroleum, fuel wastes, and lead and other metals. In addition, various biodegradable tableware and dishes have been developed; in particular, cups and plates made with a cellulose-based vegetable polymer.

Additional Information Resources:

Visit the following Web sites for more information on composting and solid waste:

- U.S. Environmental Protection Agency (EPA): <www.epa.gov>
- U.S. EPA, Office of Solid Waste site on composting: <www.epa.gov/compost>
- Cornell University composting site: <http://compost.css.cornell.edu/composting_homepage.html>
- U.S. Composting Council Web site: <www.compostingcouncil.org>

To order the following additional documents on municipal solid waste and composting, call EPA toll-free at (800) 490-9198 or look on the EPA Web site <www.epa.gov/epaoswer/osw/publicat.htm>.

- *Innovative Uses of Compost Erosion Control, Turf Remediation, and Landscaping* (EPA530-F-97-043)
- *A Collection of Solid Waste Resources* on CD-ROM

Compost Critters

Objective

To teach students that nature can "recycle" its own resources.

Activity Description

Students will search for and observe some of nature's recyclers at work, learning what role each plant or animal plays in the recycling process.

Materials Needed

- An outdoor area, such as a yard, park, or garden, that offers access to some of the following: rocks, trees (dead and living), leaf litter, mushrooms
- One or two teacher's aides or parents to help facilitate the outdoor adventure (optional)
- Several sheets of drawing paper and pencils or crayons per student
- One clear viewing container with holes

Key Vocabulary Words

Decay
Mushroom
Millipede
Fungi
Lichen

Duration

Outdoor expedition:
1 hour
In-class follow-up:
30 minutes

Skills Used

Observation/classification
Motor skills

Activity

Step 1: Visit your chosen outdoor area prior to the class trip in order to make sure it is suitable for viewing nature's recyclers. Scout out four specific "stations" for the students to visit, including a live tree, an old decomposing log, a large rock (or board) in the soil, and a leaf-covered patch of soil. To draw insects to a specific spot, you might want to plant a log or board in the soil several days in advance.

Step 2: Discuss recycling with the students and explain the following concepts (refer to the Teacher Fact Sheet titled *Composting* on page 141 for background information):

- Why we recycle and why nature also needs to recapture the value of its organic waste.
- What kinds of "trash" get "recycled" in nature.
- Who recycles these materials. Discuss the plants and animals, such as snails, slugs, beetles, millipedes, earthworms, fungi, pill-bugs, snowbugs, mushrooms, and lichen that perform nature's recycling work.

Step 3: Divide the class into small groups of three to four students. Explain that the students are now adventurers on a mission to locate and study nature's recyclers at work. Remind students that it's very important to observe, but not touch or disturb the recyclers or their habitat.

Step 4: Lead the students to your predetermined outdoor area and stop at each of the four stations. At each station, first lead a discussion (see below) and then give each group

of students the chance to get up close and make individual observations. A list of suggested topics and discussion questions for each station follows:

Station #1–Live Tree

- Ask students what makes the tree grow. Where are its roots? Where does it get its food from?
- Will the tree live forever?
- Are its leaves falling to the ground?

Station #2–Dead, Decaying Log

- Ask students how this tree is different from the live one.
- Have them touch and smell its bark. How is it different than the live bark? Is it dry or damp?
- Do the students see evidence of the wood being eaten? By what?
- Have the students look in the crevices and cracks for any of nature's recyclers at work. If they see ants, spiders, millipedes, mushrooms, etc., ask them the following questions:
  - — Is it a plant or animal?
  - — What's its name?
  - — How does it move? How many legs does it have?
  - — What color is it?
  - — Why is it living under this dead log? What does it eat?
  - — How many of these creatures are living together?
- If it's possible (and safe), capture a few of these recyclers in your clear container and let the students view them up close. You may want to impose an item limit to prevent too much disruption for the critters. Students could draw the recyclers they see in nature or wait until they return to the classroom and draw from memory. Make a point of returning the creatures safely to their homes after the viewing is over.

Station #3–Large Rock or Board

- Have the students watch as you carefully lift the rock from its position. Ask students to look at what's underneath it.
- What's it like under the rock? Is it dark and moist?
- Can the students see any of nature's recyclers at work here? If they do see life, ask them the same questions as above:
  - — Is it a plant or animal?
  - — What's its name?
  - — How does it move? How many legs does it have?
  - — What color is it?
  - — Why is it living under this rock or board? What does it eat?
  - — How many of these creatures are living together?

Station #4–Leaf Litter and Soil

- Have the students use their hands to dig through the leaves and into the soil.
- Ask them to compare these leaves to the leaves still on the live tree. How are they different? Are these leaves older? Are they wet or dry?
- Have the students look for evidence of nature's recyclers; again, identify and discuss any animals or plants that they find.
- Ask the students to feel and smell the soil. How does it compare to the dead log they visited earlier?

Step 5: Before returning to the classroom, visit the live tree station again. Ask students to think again about where this tree gets its food. Discuss how the decaying log, busy creatures, and moist, rich soil all play a role in keeping the tree alive.

Assessment

1. Back in the classroom, pass out paper and colored pencils or crayons to the students. Have each student draw one of the recyclers he or she saw outside. Ask each student to verbally describe to the class how this creature moves, what it's called, and what recycling role it plays in nature.
2. Ask the students how they are like nature's recyclers. Do they recycle anything at home? How does it get reused?
3. Have the students draw a tree in different stages of its life, showing the tree 1) budding, 2) in full growth, 3) with leaves falling, 4) as a dead tree, having fallen as a log and decaying back into the earth, and 5) as a new tree growing from the soil.

Enrichment

1. Engage students in a role-playing activity. Have students pretend that they are different recyclers (ants, millipedes, worms, mushrooms, spiders). Ask the students how these animals or plants moved or behaved. Have the students imitate this behavior.
2. Study nature's recyclers in the winter by collecting some leaf litter, bringing it inside, and warming it with a lamp. Dormant recyclers, such as millipedes, ants, spiders, and worms will come to life under the heat.
3. Conduct another nature walk, this time giving each student a recyclable paper bag. Have them collect dead leaves, sticks, nuts, or other teacher-approved items on their walk. When students return to the classroom, discuss what role these items have in nature and in the natural cycle of life. Is the item dead or alive, what is it called, is there any evidence of nature's recyclers at work? Help them glue or tape these items on a piece of construction paper and display them. Have the students perform leaf rubbings by placing a leaf under a piece of paper and coloring over it to reveal its shape and texture. Ask the students to explore how each leaf is similar or different from others.

Compost Chefs

Objective

To teach students how composting can prevent food scraps and yard trimmings from being thrown away and how different components, such as air, moisture, and nitrogen, affect composting.

Activity Description

Students will create four compost bins that differ in their amounts of air, moisture, and nitrogen. Students will observe and record the differences these conditions cause in the composting process.

Materials Needed

- Four thin, plastic buckets (5 gallons each) or other plastic container (e.g., milk jug)
- One hand drill or punch-type can opener
- One copy of the *Compost Chef* worksheet per student
- Grass clippings (shredded, if possible)
- Vegetable and fruit peels
- Weeds (shredded, if possible)
- Hay (shredded, if possible)
- Sawdust
- Coffee grinds
- Thermometer
- Bloodmeal
- One marker or pen
- Tape
- Four pieces of construction paper (3 by 5 inches each)
- Garden trowel

Key Vocabulary Words

Compost
Nitrogen
Oxygen
Decompose
Bedding
Organic

Duration

Set-up: 1 hour

Follow-up: 15 minutes to 1 hour on an occasional basis for up to 4 weeks

Skills Used

Computation
Observation/classification
Motor skills

Activity

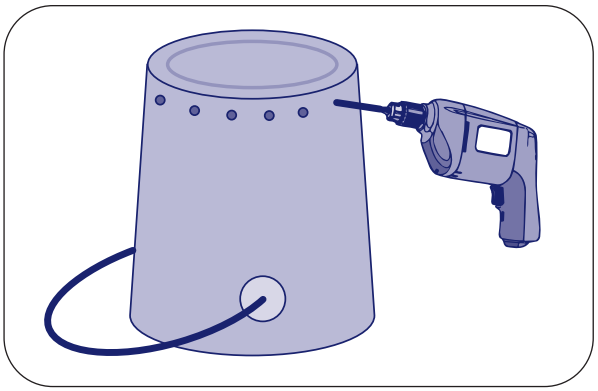
Step 1: Photocopy and distribute one copy of the *Compost Chef* worksheet to each student. Introduce the following concepts (refer to Teacher Fact Sheet titled *Composting* on page 141 for background information):

- Explain to the class what compost is and how it is made.
- Discuss why composting is important in managing and reducing trash that is sent to landfills.
- Explain how composting works, and how nitrogen, oxygen, and water all play a part in the creation of compost.

Journal Activity

Ask students to pretend they are gardeners. Ask them if they would use compost to help their gardens grow. Why or why not?

Step 2: Pick an appropriate project space. This activity can either be conducted in an indoor area of the classroom that has been covered with a protective drop cloth or in a designated area outside of the school. If you choose to leave the compost buckets outside, make sure the chosen area will not be disturbed by recess or after-school activity. Use the hand drill and carefully poke several holes in the sides (near the bottom) of three of the buckets or milk jugs.



Step 3: Have the students sit in a circle within view of you and the compost buckets. Divide the class into four groups and assign a group of students to each bucket. Using the construction paper and marker, label the buckets "one" through "four."

Step 4: Work with each group of students to set up the buckets. As each mixture is created, discuss its ingredients and ask students to record the "recipe" on their *Compost Chef* worksheets. Following are directions for setting up each bucket:

Bucket #1–Compost lacking nitrogen.

- Place mostly "brown" carbon-containing materials in the bucket, such as dead leaves, straw, and coffee grounds. On top, add a few vegetable and fruit peels.
- Moisten, but do not soak, the mixture with water.

Bucket #2–Compost lacking moisture.

- Place a mixture of "green" grass clippings (make sure they are dry), bloodmeal, and vegetable and fruit peels in the bucket.
- Place a few layers of "brown" dead leaves, straw, and coffee grounds into the mixture.
- Do not add any water.

Bucket #3–Compost lacking air circulation.

- Use the bucket without the holes.
- Place several layers of mostly high-nitrogen grass clippings, bloodmeal, vegetable peels, and fruit peels in the bucket.
- Moisten the mixture with water.

Bucket #4–"Perfect" Compost.

- Layer (in an alternating pattern) leaves, coffee grounds, straw, and vegetable and fruit peels, and a small amount of grass clippings in the bucket.
- Moisten the mixture with water.

Step 5: Explain that, as compost chefs, the students must monitor their creations. Give each group written instructions on how to care for its compost bucket over the next few weeks. For example:

Bucket #1

- Use a garden trowel to stir your compost mixture regularly: once every 3 days for the first 2 weeks, then once per week.
- Add a dash of moisture to your compost mixture with a sprinkle of water every other week.

Bucket #2

- Use the garden trowel to stir your compost mixture regularly: once every 3 days for the first 2 weeks, then once per week.
- Keep your compost mixture dry.

Bucket #3

- Add a sprinkle of water to your compost mixture every week.
- Make sure you don't stir your mixture.

Bucket #4

- Add a sprinkle of water to your compost mixture every week.
- Use the garden trowel to stir your mixture regularly: once every 3 days for the first 2 weeks, then once per week.

Step 6: At each interval of stirring or watering, have all of the groups visit each compost bucket and record their findings, including temperature, appearance, and smell. Students can use their *Compost Chef* worksheets for this task.

Step 7: After 4 weeks, have the students use the trowels to dig into each compost pile and examine it closely. Ask them to compare and contrast the compost in each bucket. Ask students which mixture decomposed the most.

Step 8: Use the finished compost from Bucket #4 as soil for classroom plants or a garden. Have students explore how compost aids new vegetative growth.

1. Ask students to list the most important ingredients for a good compost pile (nitrogen, water, and air circulation). Have them explain what role each ingredient plays in decomposition. Ask each group to name the missing ingredient in its mixture (Group #4 won't have a missing ingredient).
2. Have the students explain how composting reduces the amount of waste that we send to landfills.
3. Ask students to think of places in nature where composting might occur naturally.

1. Collect and evaluate the data on each student's *Compost Chef* worksheet. Have the students create charts or graphs based on the temperature data they collected. Which pile had the highest mean temperature? What does a high temperature mean in terms of decomposition?
2. Explore composting as a natural cycle. Study the nitrogen cycle and have students make diagrams of its components. (The nitrogen cycle is the continuous cyclic progression of chemical reactions in which atmospheric nitrogen is compounded, dissolved in rain, deposited in soil, assimilated, and metabolized.) Use composting as a lead-in to discuss other natural cycles.
3. Start a schoolwide compost bin using the appropriate wastes from school lunches. Have students decide which wastes can be added to the pile and have different classes watch over and stir the pile each week. Have each participating class start a small flower garden plot, using the compost as a soil amendment.

Compost Chef

Name: _____

Bucket #1

Week 1
Temperature:
Appearance:
Smell:

Week 2
Temperature:
Appearance:
Smell:

Week 3
Temperature:
Appearance:
Smell:

Week 4
Temperature:
Appearance:
Smell:

Ingredients:

Bucket #2

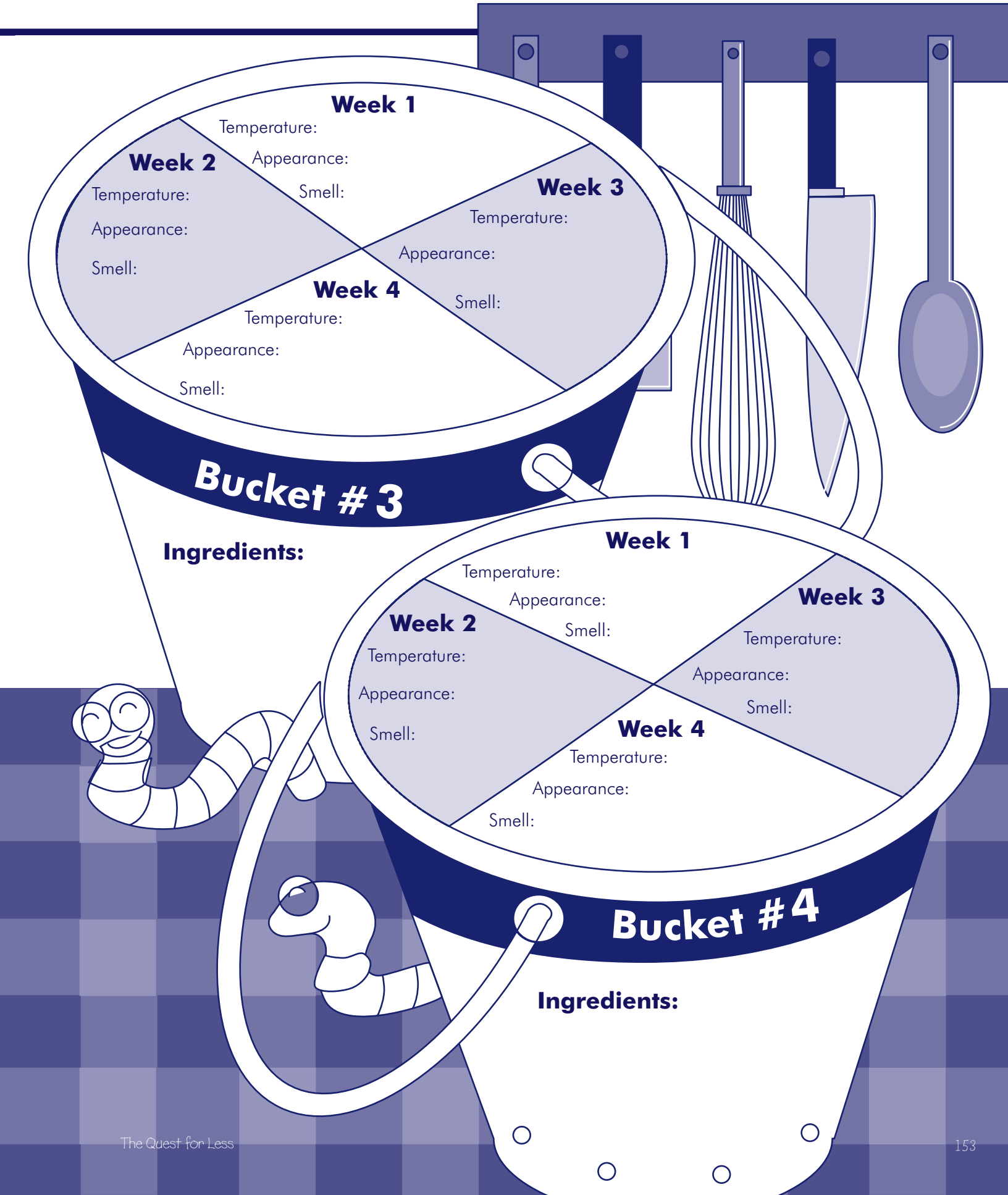
Week 1
Temperature:
Appearance:
Smell:

Week 2
Temperature:
Appearance:
Smell:

Week 3
Temperature:
Appearance:
Smell:

Week 4
Temperature:
Appearance:
Smell:

Ingredients:


Week 1
Temperature:
Appearance:
Smell:
Week 2
Temperature:
Appearance:
Smell:
Week 3
Temperature:
Appearance:
Smell:
Week 4
Temperature:
Appearance:
Smell:
Bucket #3
Ingredients:
Week 1
Temperature:
Appearance:
Smell:
Week 2
Temperature:
Appearance:
Smell:
Week 3
Temperature:
Appearance:
Smell:
Week 4
Temperature:
Appearance:
Smell:
Bucket #4
Ingredients:

science

math

Compost Crops

Prerequisite: This activity involves the use of previously made compost. Your students can use the compost they made from completing one of the following activities: Compost Chefs or Worms at Work.

Objective

To teach students how composting can prevent food scraps and yard trimmings from being thrown away and to show them the usefulness of compost in gardening.

Activity Description

Students will assess the effectiveness of compost as a soil amendment by planting and comparing two garden plots—one that relies just on dirt and one that relies on their homemade compost.

Materials Needed

- *Compost* (See prerequisite above)
- Two 4- by 4-foot garden plots in the schoolyard
- Two packets of flower seeds (have your students vote on the type and color)
- Two seed packets of a vegetable that grows well in your locale
- One watering can
- Two garden trowels
- One copy of the *Compost Crop* worksheet per student
- One tape measure or ruler

Key Vocabulary Words

Decompose
Compost
Root
Nutrient

Duration

Setup: 1 hour
Follow-up each week: 15 minutes

Skills Used

Computation
Observation/classification
Motor skills

Activity

Step 1: Locate and mark the two schoolyard garden plots you plan to use, making sure they receive plenty of direct sunlight. Secure permission for gardening from the proper school authorities.

Step 2: Discuss composting with the students and explain the following concepts (refer to the Teacher Fact Sheet titled *Composting* on page 141 for background information):

- Recap how the students made the compost and what materials they used.
- Discuss how this compost can now be used in a garden.
- Explain why compost can be more effective than just natural soil.

Step 3: Take the class outside to the garden plots and divide the students into two groups. Explain how the composting experiment will work. Tell one group that they will only add water to the soil to help their plants grow. Give the other group a bucket of compost and tell them to use the trowels to mix it into their soil before watering it.

Journal Activity

Ask students to pretend they are world-famous gardeners giving an interview about the secrets of their success. How do they make their plants grow so well?

Step 4: Have each group plant flower seeds and vegetable seeds according to packet instructions in their respective plots.

Step 5: Ask the students to predict which plot will grow better and faster. Have them record their predictions and reasoning on their *Compost Crop* worksheets.

Step 6: Break each of the two groups into pairs of students and assign each pair a week during which they are gardeners. During that week, those students are responsible for visiting their group's plot each day. They should water it and use the tape measure or ruler to record any changes in plant growth on their *Compost Crop* worksheets. Create a gardener calendar for the classroom to remind students when it's their turn to watch over the plots.

Step 7: After 4 or 5 weeks, have the entire class visit the garden plots again. Discuss which plot's plants grew faster. Ask student volunteers to gently dig up one plant from each plot. Have the students examine and compare the root structures of each plant. Have several students dig around in the plots' soil, discuss the differences in texture or moisture they find, and have them notice how many earthworms or bugs they find.

Step 8: If the vegetables in the plot are ripe, pick them and have a class snack from the compost harvest.

Assessment

1. Have students list the benefits of composting, both from the standpoint of preventing waste and as a garden soil supplement.

Enrichment

1. Use the two garden plots as a lead-in to a more in-depth science lesson on soil and compost. Compare the relative amounts of materials in different soil samples. Have student volunteers collect a handful of soil from each plot. For each sample, fill a liter (or quart) jar about one-quarter full of soil, then add water to about the three-quarter level. Screw the lid on tightly and shake hard for about a minute. Let the jars stand for several minutes. The mixture will separate into layers, with the largest particles (gravel and sand) settling on the bottom, and finer particles (clay and silt) settling above. Organic matter—leaves, twigs, and any animal matter—will float on top of the water. Discuss the differences between the soil and compost/soil plot samples. Explore the components of your local soil and compost.
2. Have the students compile their measurements and recordings from their *Compost Crop* worksheets on the board. Depending on the age group, ask all of the students to make graphs charting the growth in each plot. Ask them why plants in the compost plot grew more quickly.
3. Discuss the root structures of the plants from the different plots. Ask students if the plant from the compost plot was more developed in its root structure? Why?
4. Ask the students to think about the differences in the soil of the two plots. Did they see more earthworms in the compost plot? Why? Why would these creatures be attracted by the compost? How did the presence of earthworms affect the growth of the plants?
5. Start a schoolwide compost bin using the appropriate wastes from school lunches. Have students decide which wastes can be added to the compost pile and have different classes watch over and stir the pile each week. Have each participating class start a small flower garden plot, using the compost as a soil amendment.

Name: _____

Compost Crop Worksheet

Plot #	Amount of Water Added	Soil Status (How It Looks and Smells)	Presence of Plant Growth? Which Plants?	Measurement of Plant Growth (mm)	Thoughts or Observations
Day 1					
Plot #1 (just soil)					
Plot #2 (compost and soil)					
Day 2					
Plot #1 (just soil)					
Plot #2 (compost and soil)					
Day 3					
Plot #1 (just soil)					
Plot #2 (compost and soil)					
Day 4					
Plot #1 (just soil)					
Plot #2 (compost and soil)					
Day 5					
Plot #1 (just soil)					
Plot #2 (compost and soil)					

Worms at Work

Objective

To teach students that food scraps and yard trimmings can be made into compost instead of being thrown away.

Activity Description

Students will create a compost bin using worms and food scraps and monitor changes in the bin over time.

Materials Needed

- Large plastic bin (about 8 to 16 inches deep) with holes in the bottom for aeration
- Tray for underneath the bin
- Two bricks or other large sturdy objects
- 9 to 14 pounds of newspaper
- One bag of potting soil
- 1 pound of red worms
- Food scraps (such as bread, vegetables, fruits, eggshells, grains, coffee grounds, tea bags) Do NOT include meat, bones, mayonnaise, fish, peanut butter, candy, or nonfood items
- Tarp or drop cloth
- Bucket or other carrying container
- Household gloves (optional)
- Copy of *Vermicomposting Data Sheet* for each student

Key Vocabulary Words

Compost
Vermicomposting
Castings
Decompose
Bedding
Organic

Duration

Setup: 1 hour
Follow-up: 15 minutes to 1 hour on an occasional basis

Skills Used

Computation
Observation/classification
Motor skills

Activity

Step 1: Explain to the class what compost is and how it is made (refer to the Teacher Fact Sheet titled *Composting* on page 141). Discuss the use of worms, the need for and use of organic waste, and other vocabulary words. During the course of this lesson, inform students of good and bad foods to use in composting, as well as the reason why it is better to compost than to throw food scraps away.

Step 2: Place bin on top of two bricks and put tray under bin.

Step 3: Have the students tear each sheet of newspaper lengthwise into strips that are 1 to 3 inches wide and place half of the pile in the bin.

Step 4: Have the students multiply the number of pounds of newspaper by 3 to determine the total amount of water needed (a pint of water weighs a pound, and a gallon of water

Journal Activity

Have students write a poem, such as a limerick, that describes what compost looks like and how it feels when touched.

weighs 8 pounds). Then add half of the water to the bin with newspapers.

Step 5: Sprinkle two handfuls of soil and the rest of the newspaper and water. Have the students mix the contents well and distribute evenly in the bin.

Step 6: Gently place the worms on top of the bedding, spreading them evenly. Keep the bin uncovered so the students will see the worms moving down into the bedding to avoid light.

Step 7: Use the attached data sheet to record all activities surrounding the worm bin, including the date the bin was set up, the number of worms (or pounds of worms) added to the bin, and the number of people contributing food scraps (number of people in the class). For the remainder of steps for this activity, have students record the date and day food is added, including the type of food and its weight, as well as the amount of water added. The compost bin should always remain moist.

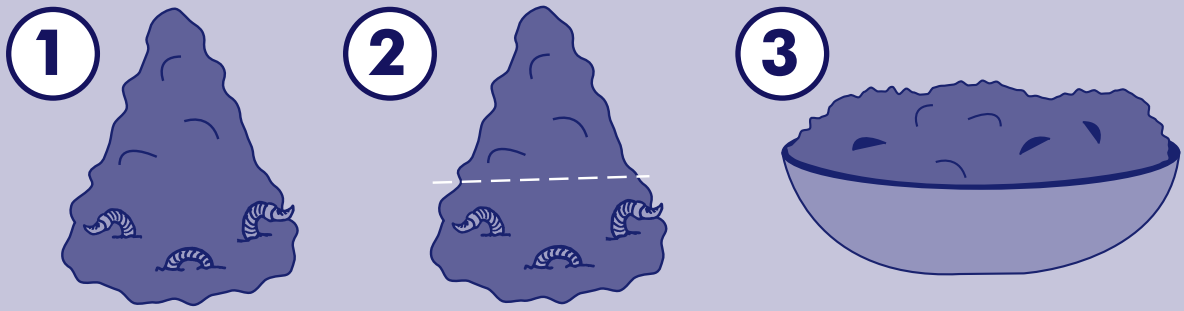
Step 8: Use food scraps that you brought from home or that you asked students to bring from home or save from school lunch, and have students add them to the bin. Food can be added daily, weekly, or monthly. Do not overload the system; bury food relatively evenly amongst the different "plots." On the data sheet, instruct students to keep track of how much food they are providing the worms and where it is placed (see diagram on data sheet).

Step 9: Place a sheet of newspaper over the top of the bin to prevent flies from circulating near the area. Store the bin in a cool place out of direct sunlight, and keep the lid tightly shut.

Step 10: Have students check the bin frequently as they add food scraps to see the changes that occur. After a period of 3 to 6 months, depending on the size of the container, most of the food and bedding will be transformed into worm castings, the nutrient-rich waste materials that worms excrete.

Step 11: In order to harvest the compost, or humus, for use (if you choose to), you must change the bedding and temporarily remove the worms. Spread out a tarp or drop cloth in an open area and dump out the entire contents of

Step 11: How To Harvest Compost



1. Divide compost materials into several cone-shaped piles (larger on the bottom).
2. Scoop off the material from the top of the piles.
3. Put the castings into a container to carry out to the garden.

the bin. Have students help you divide the materials into several cone-shaped piles (larger on the bottom, so the worms will burrow into it and avoid the light). Direct students to scoop off the material from the tops of the piles, and put the castings into a container to carry out to the garden (see illustration on the previous page for help). Repeat this procedure until most of the compost is harvested.

Step 12: Have students put worms back in the bin, along with any uncomposted food and old bedding. Your class can start a new stock of bedding and add in any additional worms to begin the process again.

Step 13: Create a garden in which to use the compost as a soil amendment, or use the compost on the schools' beds or lawn.

NOTE: Other critters may make their way into the compost bin. Many are beneficial, including mold, bacteria, sow bugs, beetle mites, white worms, snails and slugs, flies, round worms, and millipedes. You do NOT want the following in your bin, however: flat worms, ground beetles, centipedes, ants, and pseudo scorpions. If you find any of these organisms, start over.

1. Ask students to define and describe decomposition.
2. Ask students why it is beneficial to compost items instead of throwing them away.

Ask the students to make observations about the worm bin each week. Do smaller pieces of food tend to break down faster than larger ones? What does the compost smell like? What organisms do they notice? Are the worms multiplying?

1. Have students take the temperature of the worm bin once a week to determine the variations that occur while food is composted. Use a thermometer that can measure up to 170°F. Have the students create bar graphs showing the increase or decrease in temperature over time.
2. Let students use a pH paper to test the acidity of the worm bin once a week. Does the pH change based on the foods that are added? Have the students keep a record of the foods that are added and the pH and chart a graph showing the correlation. If the soil is too acidic, the worms may try to leave the bin. Try adding a little lime.
3. Give students gloves to gently examine the critters inside the bin once a week. You might also examine a sample of the soil under a microscope (at the beginning of composting, bacteria are present that help break down the food; later larger organisms such as sowbugs and round worms play a larger role.) Obtain an identification guide to invertebrates and insects and see how many you can identify. Have students draw the different kinds of critters and discuss the differences in each (number of legs, body parts, function).

Student Handout

Name: _____

Vermicomposting Data Sheet

Date bin was set up: _____

Number of worms (or pounds of worms) added to bin: _____

Number of people contributing food scraps on a regular basis: _____

Date	Day	Weight of food added	Type of food added	Amount of water added	Buried in site #	Notes

(If you run out of spaces, get an extra copy of this sheet from your teacher.)

On the back of this paper, draw the worm bin, including its dimensions, and assign plots to certain sections so you can track decomposition of food placed in each numbered area.

Harvest date: _____

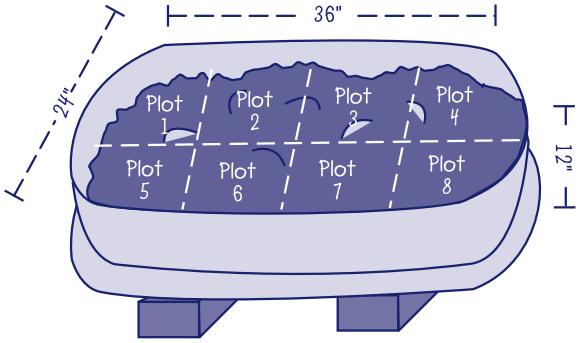
Total days: _____

Total weight of food buried: _____

Weight of uneaten food left over: _____

Average weight buried per day: _____

Example:



CHAPTER 2.4

Landfills and Combustion

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Teacher Fact Sheet: Combustion 169

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A Landfill Is No Dump (Grades 3-6) . . 177

Energy Expedition (Grades 4-6) 181

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Greenhouse Gases Be Gone (Grades 6-8) 191

Grade • Subject • Skills Index

Activity Name	Luscious Layered Landfill	A Landfill Is No Dump!	Energy Expedition	The Great Disposal Debate	Greenhouse Gases Be Gone
Grade Range					
K					
1	✔				
2	✔				
3	✔	✔			
4	✔	✔	✔	✔	
5		✔	✔	✔	
6		✔	✔	✔	✔
7				✔	✔
8				✔	✔
Subjects Covered					
Math					✔
Science	✔	✔	✔		✔
Language Arts			✔	✔	
Social Studies	✔	✔		✔	✔
Art					
Health					
Skills Used*					
Communication				✔	
Reading			✔	✔	✔
Research				✔	✔
Computation					✔
Observation/ Classification	✔	✔			✔
Problem Solving		✔	✔	✔	✔
Motor Skills	✔				

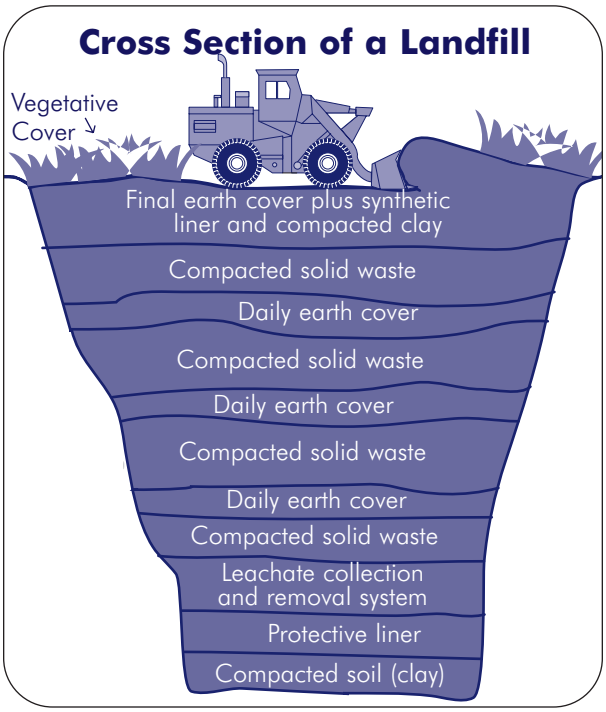
*See Glossary of Skills for more details.

Landfills

What Is a Landfill?

A landfill is a large area of land or an excavated site that is specifically designed and built to receive wastes. Today, about 56 percent of our country's trash is disposed of in landfills (EPA, 2003). Items such as appliances, newspapers, books, magazines, plastic containers, packaging, food scraps, yard trimmings, and other wastes from residential, commercial, and some industrial sources can be disposed of in **municipal solid waste landfills**. Municipal solid waste landfills can also accept some types of hazardous waste, such as cleaning products, paint, and chemicals, as well as some industrial wastes from certain businesses. Many states and communities, however, promote the safe collection of these hazardous wastes through local programs. (See "Are There Landfills for Hazardous Waste?" on page 166 for more information.)

In the past, garbage was collected in **open dumps**. These uncovered and unlined sites allowed **leachate**, a liquid formed by **decomposing** waste, to soak into the soil and **ground water**.



Key Points

- Landfills are the most common form of waste disposal and are an important component of an integrated waste management system.
- Federal landfill regulations have eliminated the open dumps of the past. Today's landfills must meet stringent design, operation, and closure requirements.
- Landfills that handle hazardous wastes are specially designed with two sets of liners and two leachate detection systems.
- After a landfill is capped, the land may be used for recreation sites such as parks, golf courses, and ski slopes.
- Methane gas, a byproduct of decomposing waste, can be collected and used as fuel to generate electricity.

Open dumps also attracted rodents and insects, emitted odors, and created fire hazards. Most of these small and unsanitary dumps have been replaced by large, modern facilities that are designed, operated, and monitored according to strict federal and state regulations. Today's landfills eliminate the harmful and undesirable characteristics of dumps to help protect public health and the environment.

In addition to being safer for the environment and neighboring communities, these larger landfills hold more trash than the dumps of the past. In 2001, about 1,850 municipal solid waste landfills were operating in the United States (EPA, 2003). While this number is significantly smaller than the number of landfills 25 years ago, new landfills—often called megafills due to their size—can accommodate significantly more garbage. This greater capacity is necessary to keep up with the steady growth of **municipal solid waste**.

Are There Landfills for Hazardous Waste?

In 2001, more than 1 million tons of hazardous waste was disposed of in landfills or surface impoundments. Hazardous waste is toxic, ignitable, corrosive, or reactive, or generated from certain industries or manufacturing processes. When it comes to disposing of hazardous waste in landfills, EPA takes additional steps to ensure environmental safety and human health.

While landfills that accept solid waste have a clay and plastic liner and a leachate system to prevent leakage, landfill owners that accept hazardous waste must take extra precautions. For example, a hazardous waste landfill must have two sets of liners, one consisting of a special plastic, and the other composed of both plastic and a thick layer of soil material. In addition, a landfill accepting hazardous waste must have two leachate detection systems instead of just one.

Before hazardous waste even reaches a landfill, however, it must be treated differently than solid waste. If hazardous waste is bound for disposal in a landfill, it is regulated under EPA's Land Disposal Restrictions program. Through this program, hazardous waste must undergo treatment that will destroy or immobilize its hazardous components before it is sent to a landfill. For example, when a business generates hazardous waste, it must either treat that waste itself, or send it to a special facility for treatment, before sending the waste to a landfill.

How Does a Landfill Work?

A typical modern landfill is lined with a layer of clay and protective plastic to prevent the waste and leachate from leaking into the ground or ground water. The lined unit is then divided into **disposal cells**. Only one cell is open at a time to receive waste. After a day's activity, the garbage is **compacted** and covered with a layer of soil to minimize odor, pests, and wind disturbances. A network of drains at the bottom of the landfill collects the leachate that flows through the decomposing waste. The leachate is sent to a **leachate recovery facility** to be treated. Methane gas, carbon dioxide, and other gases produced by the decomposing waste are monitored and collected to reduce their effects on air quality.

Landfills are regulated by federal and state laws. The federal laws dictate where landfills can be located, such as away from unstable land prone to earthquakes or flooding, and require them to be lined and have a **leachate collection system**. In addition, landfill owners must monitor and collect explosive gases; regularly test nearby ground water; and compact and cover waste with a layer of soil on a daily basis.

In addition to federal regulations, each state has its own landfill requirements, which are often more stringent than the federal laws. Many states require landfill operators to obtain a license and present a plan for how the site will be safely closed, even though the closing date might be 50 years in the future. Furthermore, federal law requires landfill owners to set aside the money to close the landfill properly and support ongoing monitoring activities. Once a landfill is capped (closed), the operator must monitor the site for gas and leachate for a minimum of 30 years after the closing date.

What Are the Benefits of Landfills?

In addition to providing a cost-effective, safe method to dispose of ever-increasing amounts of trash, landfills often provide other services to the community. For example, some landfills collect methane, a gas created by decomposing

Landfill Facts

- The first garbage dump was created in 500 BC by the ancient Greeks in Athens. Residents were required to take their trash at least 1 mile away from the city walls to dump.
- Paper takes up as much as 50 percent of all landfill space. Recycling 1 ton of newspapers would save 3 cubic feet of that space.
- In a study of waste buried for more than 15 years, Professor William Rathje of the University of Arizona found legible newspapers and chicken bones with meat still on them, proving that waste does not decompose completely in a landfill.

(Sources: The League of Women Voters' Garbage Primer, 1993; Rubbish! The Archaeology of Garbage by William Rathje, 1990; Anchorage Recycling Center, 2000)

garbage that can contribute to **global climate change**, and convert it into an energy source. In addition, after a landfill is capped and a certain amount of time has passed, the land might be reused for parks, ski slopes, golf courses, and other recreation areas.

What Are the Challenges of Landfills?

Though regulations have made landfills safer to the public and the environment, public opposition, high land prices, and environmental concerns can make it difficult to find suitable places for new landfills.

Landfills can pose other problems if not properly designed or managed. If a liner leaks, for example, the underlying soil and ground water can become contaminated. Additionally, since landfills are often located in remote areas, waste must be hauled long distances, which might result in environmental impacts from increased truck traffic (e.g., air pollution) and noise from truck traffic and the use of equipment onsite. Additionally, landfills often compete for local garbage within a given municipality. Competition can lead to reduced support for recycling and other waste reduction programs.

Issues also might arise if a landfill is located close to a community. Many people do not want landfills near their homes. The NIMBY (Not in My Backyard) attitude can make finding a landfill site very challenging.

What Are Some Emerging Trends?

Increased waste generation requires landfill operators and managers to constantly evaluate and improve current disposal methods. One strategy to speed the rate of decomposition of landfill waste is to recirculate the collected leachate by pouring it over the cells and allowing it to filter through the rotting garbage.

Another trend that is becoming common for landfill operators is collecting methane gas from the landfill and using it as the energy source to power the landfill or selling it to a local utility provider, company, or even greenhouses. This process allows landfills to reduce their dependence on precious **fossil fuels** and save money.

A new trend that is gaining attention is **landfill reclamation**, in which old cells are excavated to recover recyclable items. This process, in which recovered recyclables, soil, and waste can be sold, reused, or burned as fuel, is a new approach used to expand landfill capacity and avoid the cost of acquiring additional land.

Additional Information Resources:

Visit the following Web sites for more information on municipal solid waste landfills:

- U.S. Environmental Protection Agency (EPA): <www.epa.gov>
- U.S. EPA, Office of Solid Waste site on disposal: <www.epa.gov/epaoswer/non-hw/muncpl/disposal.htm>
- U.S. EPA Landfill Methane Outreach Program: <www.epa.gov/lmop>
- National Solid Waste Management Association: <www.nswma.org>
- Solid Waste Association of North America: <www.swana.org>

For more information on the disposal of hazardous waste in landfills, visit:

- U.S. EPA, Office of Solid Waste site on Land Disposal Restrictions: <www.epa.gov/epaoswer/hazwaste/ldr>
- U.S. EPA, Office of Solid Waste site on RCRA Hotline Training Modules (hazardous waste land disposal units): <www.epa.gov/epaoswer/hotline/modules.htm>

To order the following additional documents on municipal solid waste, call EPA toll-free at (800) 490-3198 (TDD 800 553-7672) or look on the EPA Web site <www.epa.gov/epaoswer/osw/publicat.htm>.

- *Sites for Our Solid Waste: A Guidebook for Public Involvement* (EPA530-SW-90-019).
- *Safer Disposal of Solid Waste: The Federal Regulations for Landfills* (EPA530-SW-91-092)
- *Decision-Makers' Guide to Solid Waste Management, Volume II* (EPA530-R-95-023)
- *A Collection of Solid Waste Resources* on CD-ROM

Combustion

What Is Combustion?

Recycling, composting, and source reduction are vital activities for effective solid waste management, but 100 percent of people's trash cannot be handled by these methods. The remaining waste must be deposited in landfills or combusted (burned). Because of limited space, landfills are not always a viable option in many cities, making ***combustors*** (commonly referred to as incinerators) an important part of a community's integrated waste management system. Burning garbage can decrease the volume of waste requiring disposal by 70 to 90 percent.

Before the late 1970s, many people burned garbage in their backyards and in simple private and municipal combustors. These methods did not burn garbage completely, however, and allowed pollutants to escape into the atmosphere. With the passing of the Clean Air Act, combustor owners had to develop more effective methods of pollution control. Today's municipal waste combustors release significantly less pollutants into the air than the "backyard burners" and simple combustors. More than 100 municipal waste combustor plants currently exist nationwide, and nearly 20 percent of the municipal solid waste generated in the United States is combusted.

Key Points

- Municipal waste combustors burn waste at high temperatures to reduce its volume.
- Municipal waste combustors reduce the volume of garbage by 70 to 90 percent.
- Ash is a byproduct of combustion that must be disposed of in landfills or reused.
- Air pollution control equipment helps reduce air emissions.
- The heat produced by burning waste in municipal waste combustors can be recovered as useful energy.
- Specially designed incinerators can be used as a means of handling hazardous waste. The burning process reduces the toxicity of organic compounds in the waste.

Facts about Municipal Waste Combustors

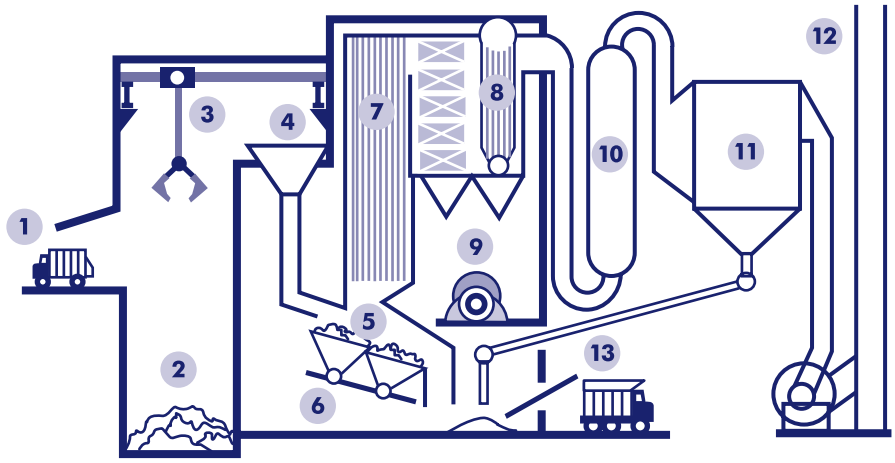
- Fire in the boiler of a combustor is often as hot as flowing lava (between 1,800 and 2,200 degrees Fahrenheit).
- In 1874, a new technology called "the destructor" provided the first combustor of municipal garbage in England.
- The first garbage incinerator in the United States was built on Governor's Island, New York, in 1885.

(Sources: Integrated Waste Services Association, 2000; Rubbish! The Archaeology of Garbage by William Rathje, 1990)

How Do Municipal Waste Combustors Work?

Municipal waste combustors dispose of trash by burning it at high temperatures. Not all municipal waste combustors are designed alike, but they function in a similar manner. Typically, a facility collects waste in a garbage receiving area or pit, where the garbage is mixed by a crane. The crane operator looks for large items that are not suitable for combustion

How Typical Combustion Facilities Work



1. Tipping area for trucks
2. Refuse pit
3. Refuse crane
4. Hopper, which sends waste to combustion zone
5. Primary combustion zone
6. Underfire air
7. Furnace
8. Heat exchanger
9. Turbine
10. Scrubber, to remove acid gases
11. Fly ash and dust collector
12. Stack
13. Bottom ash and fly ash collection and transport

Hazardous Waste Combustion

In addition to combustion facilities that accept municipal (nonhazardous) waste, specially designed incinerators, boilers, and industrial furnaces, can burn hazardous waste. Hazardous waste, which is toxic, ignitable, corrosive, or reactive, can be produced by businesses or manufacturing operations. Combustion has some key advantages as a means of managing hazardous waste. First, burning hazardous waste reduces the volume of waste by converting solids and liquids to ash. Second, the burning process destroys toxic organic compounds in waste. Third, disposal of the ash in a landfill is safer and more efficient than disposal of untreated hazardous waste. The ash generated from hazardous waste combustion must be tested and, if found to be hazardous, must be treated for remaining toxicity before it is disposed of in a landfill.

(e.g., batteries and refrigerators) and removes them from the pit. The crane operator also uses the crane to lift piles of garbage into a large chute. From the chute, garbage falls into a combustion chamber or furnace and then moves along a series of sloping grates that work like conveyer belts. The garbage is burned as it moves forward.

After garbage is burned, some matter remains in the form of ash. There are two types of ash: bottom ash and fly ash. Bottom ash is the heavier, nonburnable material, such as glass and metal, that falls through the grate after burning. Large pieces of metal accumulate in this ash and are extracted from the ash with magnets. Bottom ash accounts for about 75 to 90 percent of ash produced by incinerators. Fly ash includes lighter particles that rise with hot gases as the garbage is burned and are captured by air pollution control equipment in the stacks. All ash generated by combustion facilities must be tested to determine if it is hazardous. If it is hazardous, the ash is subject to special hazardous waste disposal regulations. If the ash is nonhazardous, it may

be deposited in landfills specially designed to store it. Currently, studies are under way to investigate ways to reuse ash; for example, to replace soil as a landfill cover (generally applied at the end of each day to minimize odor, pests, and wind disturbances). Ash might also be used in road and building construction and as part of artificial offshore reefs. Whether the leftover ash is recycled or landfilled, it takes up much less space than the same materials in their original form.

What Are the Benefits of Municipal Waste Combustors?

Most municipal waste incinerators in the United States generate energy in the form of electricity because certain materials, such as paper, plastics, wood, and packaging, make excellent fuels. Producing this energy has about the same environmental impact as energy produced from natural gas and less of an environmental impact than energy produced from oil or coal. In other words, generating energy from municipal waste combustors contributes no more pollution—and sometimes less—than processes generating electricity using natural gas, oil, or coal. Waste-to-energy plants also reduce the need to generate electricity from nonrenewable natural resources such as oil and coal.

What Are the Challenges of Municipal Waste Combustors?

Although technologies to control pollution have improved significantly, burning certain materials still produces chemicals that contribute to air pollution. To minimize emissions of air pollutants into the atmosphere, municipal waste incinerators use special equipment (e.g., scrubbers and dust collectors) to remove pollutants. To protect air quality and monitor the hazardous constituents in ash, EPA established regulations that apply to all large municipal solid waste units (those with the capacity to burn more than 250 tons of garbage per day). The regulations significantly reduce toxic air emissions such as dioxin, acid gas, lead, cadmium, and mercury.

Many people do not want incineration sites near their homes. The ***"NIMBY (Not In My Back Yard)"*** attitude makes finding appropriate sites for municipal waste combustors a challenge for many municipalities. There are, however, opportunities for the public to participate in deciding where a combustor will be located. Officials must hold a public meeting to inform the community about the size of the proposed combustor, as well as the amount of waste generation and ash to be discarded.

Additional Information Resources:

Visit the following Web sites for more information on municipal and hazardous waste combustion and solid waste:

- U.S. Environmental Protection Agency (EPA): <www.epa.gov>
- U.S. EPA, Office of Solid Waste site on disposal: <www.epa.gov/epaoswer/non-hw/muncpl/disposal.htm>
- Integrated Waste Services Association: <www.wte.org>
- Solid Waste Association of North America: <www.swana.org>

To order the following additional documents on combustion and solid waste, call EPA toll-free at (800) 490-9198 or look on the EPA Web site <www.epa.gov/epaoswer/osw/publicat.htm>.

- *Decision-Makers' Guide to Solid Waste Management, Volume II* (EPA530-R-95-023).
- *Sites for our Solid Waste: A Guidebook for Public Involvement* (EPA530-SW-90-019)
- *A Collection of Solid Waste Resources* on CD-ROM (EPA530-C-98-001)

science

social studies

Luscious Layered Landfill

Objective

To teach students how a modern landfill functions (that is, how its many layers contain garbage and prevent leakage into soil or ground water).

Activity Description

Students will construct edible models of a landfill to learn about its different layers and their functions.

Materials Needed

- One 8-ounce pliable clear plastic cup per student
- Five chocolate sandwich cookies per student
- One 8-ounce box of raisins
- One fruit rollup per student
- Two graham crackers per student
- Two red licorice sticks per student
- One package of birthday candles
- One set of matches
- One scoop of chocolate ice cream (or pudding) per student
- Two tablespoons of whipped cream per student
- One plastic knife per student
- One plastic fork per student
- One handful (per student) of a variety of small chewable candies (e.g, chocolate, peanut butter, fruit)
- One copy of *Anatomy of a Landfill* handout per student

Key Vocabulary Words

Landfill
Clay liner
Plastic liner
Leachate
Leachate collection pipes
Methane
Decompose
Rodent

Duration

1 hour

Skills Used

Observation/classification
Motor skills

Activity

Step 1: Refer to the Teacher Fact Sheet titled *Landfills* on page 165 for background information. Explain the purpose of a landfill to students and explain that they will construct their own model landfills in class. Copy and distribute the *Anatomy of a Landfill* handout. Using the handout, go over each layer's name and function with students.

Step 2: Distribute a cup and five chocolate sandwich cookies to each student. Explain that the cup represents an excavated hole in the ground.

Step 3: Have students carefully "unscrew" two of their cookies so that one half has white cream and the other is bare. Students should have two cookie halves with white cream and two cookie halves without cream. Crush the bare cookie halves into small pieces and put

Journal Activity

Ask students to list some common items that they throw away. What do they think people threw away 100 years ago? Ask them to predict what we will throw away in the future. What would they expect to find in a landfill in another country (pick a country)? Ask students to compare these answers with the United States.

them into the cup. Explain that the crushed cookies represent a layer of soil that is placed in the bottom of real landfills.

Step 4: Next, have the students take the cookie halves with white cream and break them up into two or three pieces. Direct students to place the pieces in the cup with the white cream face up. These pieces represent a layer of clay that is put on top of the soil in real landfills.

Step 5: Have students use the plastic knife to cut their fruit rollups to roughly fit the size of the top of cup and slide them into place (will push up on sides) on top of the cookies to represent a plastic liner. Plastic liners prevent leachate from escaping from a landfill into the ground. Leachate is liquid created when trash decomposes.

Step 6: Have students crush and add their graham crackers to represent a sand layer. This layer is used to prevent liquids in landfills from seeping out.

Step 7: Have students place raisins on top to represent a layer of pebbles. Like the sand layer, pebbles provide further protection against leachate leaks.

Step 8: Have students rip the licorice sticks in half and bite off both ends to represent leachate pipes. Stick pipes into pebble layer. These pipes collect any leachate that collects on top of the liners.

Step 9: Ask students to sprinkle the candies on top of the raisins. The candies represent pieces of garbage. Ask students to think about what happens when a landfill or "cup" is filled up with trash or "candies"? How can they reduce the amount of trash that they send to the landfill? (Refer to the Teacher Fact Sheet titled *Recycling* on page 101 for background information.)

Step 10: Give each student a scoop of ice cream on top of the candies. Then, have the students add one more layer of candies on top of the ice cream. The ice cream layer represents the seepage created from rain seeping through the garbage. Explain that in a real landfill, more layers of garbage or "candies" are placed on the landfill each day, so that liquid from the decomposition of the trash is continually created.

Step 11: Direct students to "unscrew" their two remaining cookies and crush another layer of the bare cookie halves, without the cream, on top of the candies and ice cream to represent soil again. (Students can eat the other cream-covered cookie halves.) This layer reduces the amount of rain water that reaches the garbage.

Step 12: Each student should use a layer of whipped cream to "cap" the landfill or cover it (as would a plastic cap) in order to prevent odor, insect, and rodent problems.

Step 13: In front of the class, stick a candle deep into your own edible "landfill" and light it. Explain that the candle represents the methane gas recovery system, which draws methane gas from the decomposing garbage. The flame represents energy that can be generated by burning the captured methane gas.

Step 14: Have students eat their landfills as a snack. When they get to the bottom of their cup, ask students to notice whether their cookie or "soil" layer is dry, or whether the ice cream or "leachate" leaked past the many layers and the fruit roll-up liner to soak the cookies. Remind students that if they built their landfill correctly, their cookies will be dry, just as in a real landfill the soil remains protected from leachate.

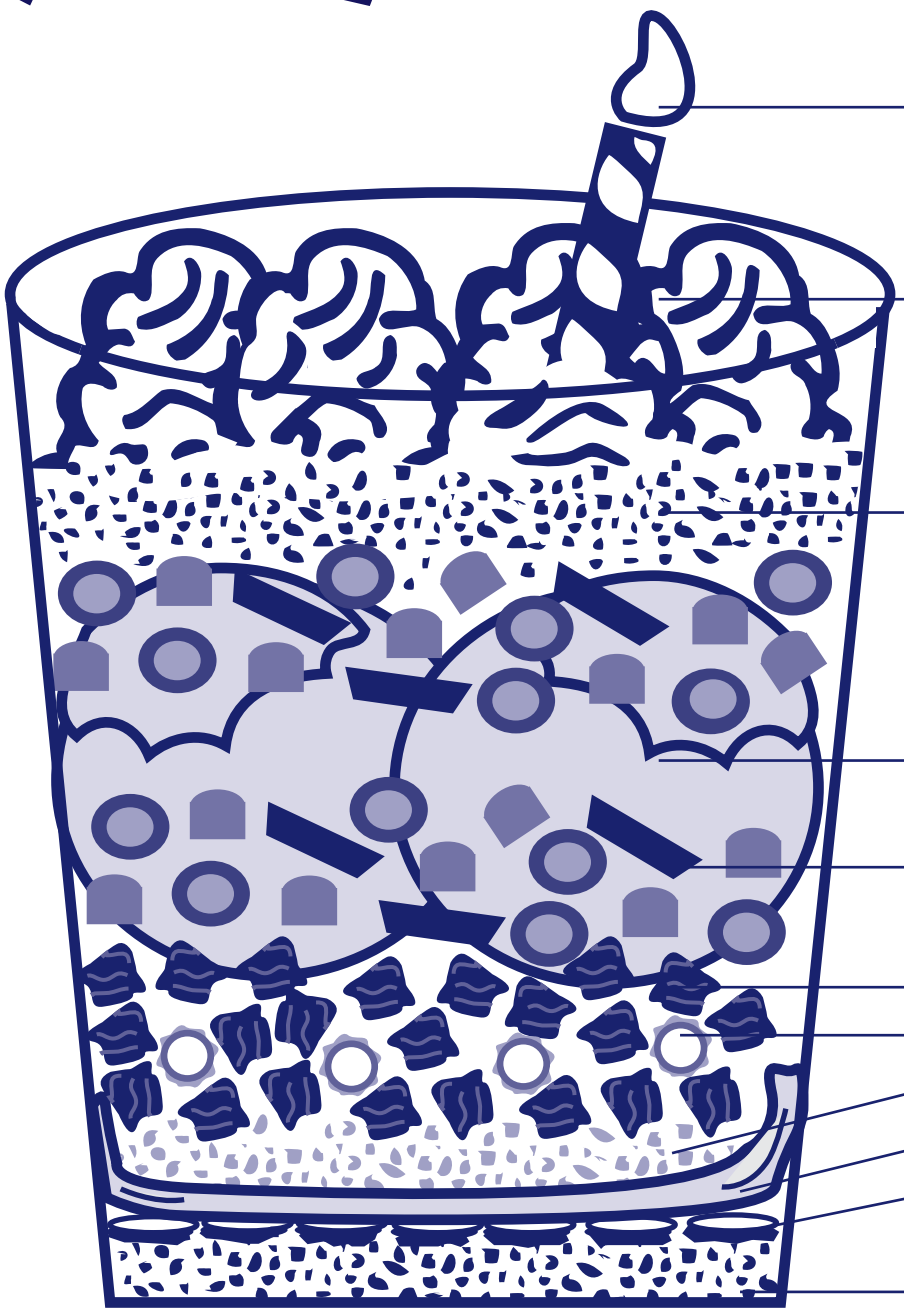
Assessment

1. After enjoying the luscious layered landfill as a snack, ask the students if they remember the purpose of all the different parts, such as the fruit roll-up, the licorice, the cookies, and your candle.

Enrichment

1. Contact a landfill in your community and take a tour. Ask to hear about all the different parts of the landfill. If your landfill recovers methane for energy, ask for a tour of the plant.
2. Have students conduct a survey of friends and family asking them where their garbage goes. Have them record peoples' responses and determine whether they are well informed. In class, discuss the survey results.

Anatomy of a Landfill



Methane gas recovery system (candle): recovers gas for energy from decomposing garbage

Landfill cap (whipped cream): prevents odor, insect, and rodent problems

Soil layer (cookie pieces): used to cover daily garbage

Leachate (ice cream): natural byproduct of decomposing garbage

Garbage (candies): added daily from communities

Pebble layer (raisins): prevents liquid from seeping out

Leachate pipe (licorice stick): collects leachate

Sand layer (graham crackers): prevents liquid from seeping out

Plastic liner (fruit rollup): prevents leachate from escaping into the ground

Clay layer (cookie pieces): absorbs any leachate (or liquid) that escapes the plastic liner

Soil layer (crushed cookies): lines the bottom of the landfill

Student Handout

science

social studies

A Landfill Is No Dump!

Objective

To teach students where garbage goes and explain the difference between unlined trash "dumps" of the past and today's specially designed landfills.

Activity Description

Students will construct models of an old-fashioned "dump" and a modern landfill in class and observe their differences.

Materials Needed

- Two plastic colanders (9 inches wide by 4 inches deep)
- Two cake pans (9 inches)
- One 10-pound bag of garden soil
- One 32-ounce bottle of distilled water
- Small pieces of typical home-generated garbage (see below)
- One package of modeling clay
- One roll of colored (red) crepe paper
- Clear tape
- One measuring cup
- One pair of scissors
- One package or roll of litmus (pH) paper
- One copy of the *Landfill Log* worksheet for each student

Key Vocabulary Words

Organic
Municipal solid waste
Landfill
Leachate
Groundwater
Turbidity
pH

Duration

Landfill creation: 1 hour
Observation over 4 weeks: 15 to 20 minutes each week

Skills Used

Observation/classification
Problem solving

Activity

Step 1: Photocopy and distribute *Landfill Log* worksheets to each student. Bring in some small pieces of garbage from your home, such as potato peels, apple cores, newspaper, and plastic yogurt containers. Introduce the following topics or concepts (refer to the Teacher Fact Sheets titled *Solid Waste* on page 47 and *Landfills* on page 165 for background information):

- Trash generation and disposal.
- How trash has been disposed of in the past and how it is disposed of now.
- Explain, in general terms, how a landfill works.
- Define each of the key vocabulary words used in the lesson.

Ask students to write a haiku or sonnet about where their garbage goes.

Step 2: Begin the exercise by asking a student volunteer to line one colander with flattened modeling clay, patting it out flat like a pie crust. Explain that this represents the liner of a sanitary, modern landfill. Do not line the second colander. Note that it represents an old-fashioned, unsanitary dump.

Step 3: Have several students cut the different garbage items you brought in from home into small pieces, about 2 inches square.

Step 4: Have a few student volunteers place this trash and the garden soil in the colanders in alternate layers until the colanders are full. For each layer, add 1 inch of garbage covered by 1/4 inch of dirt. Add several strips of red crepe paper as one layer toward the bottom of the colanders and cover them with more dirt. (The red crepe paper will emphasize the seepage of water through the unlined dump.)

Step 5: Place cake pans under the colanders to collect the seepage.

Step 6: Have students simulate "rain" on the "landfills" by pouring 1 cup of water onto each colander twice a week for 4 weeks. Ask students to observe the changes that take place. Pay particular attention to any water that collects in the cake pans. The unlined colander's seepage should be observable and colored by the crepe paper. The lined colander should not leak.

Step 7: After every "rain" session, have the students use a measuring cup to measure the water that leaked out of the unlined colander. Have students observe and record the water's color and turbidity. Ask for volunteers to test the pH of the collected water with litmus paper. Ask students to record results and observations in their *Landfill Logs*. For comparison purposes, have students test and record the pH of the distilled water.

Step 8: Next, have student volunteers put the "dirty" water from the unlined colander in a plastic cup. Fill another plastic cup with distilled water.

Step 9: Ask students to pretend that the dirty water or "leachate" had escaped an unlined landfill and reached surrounding plants and animals. Ask them what effect they think the liquid would have on animal or plant life. Ask students to predict how a piece of celery (representing a plant) would react to the leachate or "dirty" water.

Step 10: Insert two pieces of celery—one into the leachate cup and one into the distilled water cup. Point out to students how the celery stalk absorbs all of the color from the crepe paper, or dirt and toxins, of the leachate. Have students record observations about the process and the differences between the two pieces of celery.

Assessment

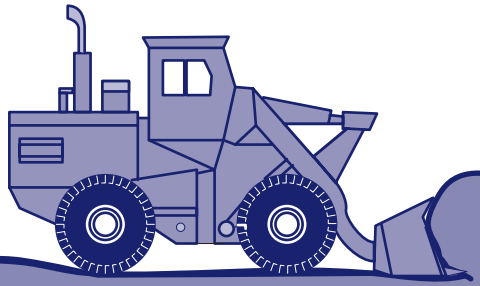
1. Ask students to explain the differences between the mini-landfills.
2. Ask students to refer to their *Landfill Logs*. How did the color, turbidity, and pH of the leachate and the distilled water differ? Why?
3. Have students describe how an unlined landfill or "dump" can pollute ground water and surrounding soil.
4. Ask students to decide which landfill is better for the environment and why. Which kind of disposal facility would they rather have in their neighborhood?
5. Ask students to define the key vocabulary words of this lesson. Conduct a spelling bee using these words.

Enrichment

1. Take a field trip to a local landfill. Have kids tour the facility and learn firsthand how it operates. When you return, have students write a paragraph about their visit, including five new facts about landfills that they learned.
2. Contact your state solid waste or environmental agency to find out how many landfills are in your state. If one is located near you, ask how many tons of trash it accepts per day or per year and its lifetime maximum capacity. Have students use data obtained from the agency to calculate how quickly the landfill is filling up. Have students make graphs to show how much longer it can accept garbage at its current rate.

Landfill Log

Name: _____



Observations

Date	Amount of Leachate	pH of Leachate	pH of Distilled Water	Color of Leachate	Turbidity of Leachate	Celery in Leachate (one-time observation)	Celery in Distilled Water (one-time observation)
Week 1 Rain 1 Rain 2	½ cup	9	7	brown and red	murky and filled with particles		
Week 2 Rain 1 Rain 2							
Week 3 Rain 1 Rain 2							
Week 4 Rain 1 Rain 2							

science

language arts

Energy Expedition

Objective

To introduce students to the concept of energy and teach them about its connection to trash.

Activity Description

Students will complete the *Energy Expedition* worksheet individually or in pairs.

Materials Needed

- One photocopy of the *Energy Expedition* worksheet per student
- One pencil or pen per student

Key Vocabulary Words

Potential	Combustion
Fossil	Methane
Coal	Solar
Gas	Water
Trash	Oil

Duration

1 hour

Skills Used

Reading
Problem solving

Activity

Step 1: Distribute one copy of the *Energy Expedition* worksheet to each student. Introduce the concept of energy—what it is, what it's used for, and where it comes from. Next, discuss the link between energy and trash; explain how we can capture methane gas from landfills to burn as energy for the community or local businesses. In addition, discuss how we can capture energy by burning our trash in combustion facilities. Refer to the Teacher Fact Sheets titled *Landfills* on page 165 and *Combustion* on page 169 for background information.

Step 2: Depending on student ability levels, use the Teacher Answer Key to go over the key vocabulary of this activity in advance, discussing each word and its meaning with the class. This will help them correctly complete the written activity later.

Step 3: Direct students to complete the *Energy Expedition* worksheet, working either individually or in pairs.

Journal Activity

Have students keep an energy diary for one week. Ask them to record every time they use energy in a day (for example, turning on lights, using a car or bus). Where could they have saved energy (for example, riding a bike instead of using a car)?

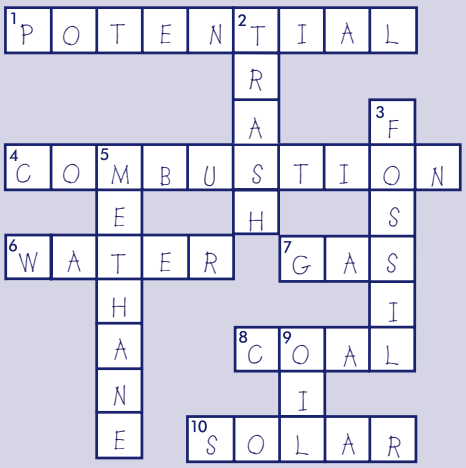
Assessment

1. Collect the *Energy Expedition* worksheets and assess students' work.
2. Ask students to list at least four different sources of energy.

Enrichment

1. Visit a waste-to-energy facility as a field trip. Have students write summaries that explain how the facility works.
2. Divide the class into groups and assign them each an energy concept (such as those introduced in the *Energy Expedition* worksheet.) Ask each group to conduct research on their topic and prepare a presentation to teach the class about their findings.
3. Conduct a spelling bee using the energy words featured on the *Energy Expedition* worksheet.

Crossword Puzzle Key

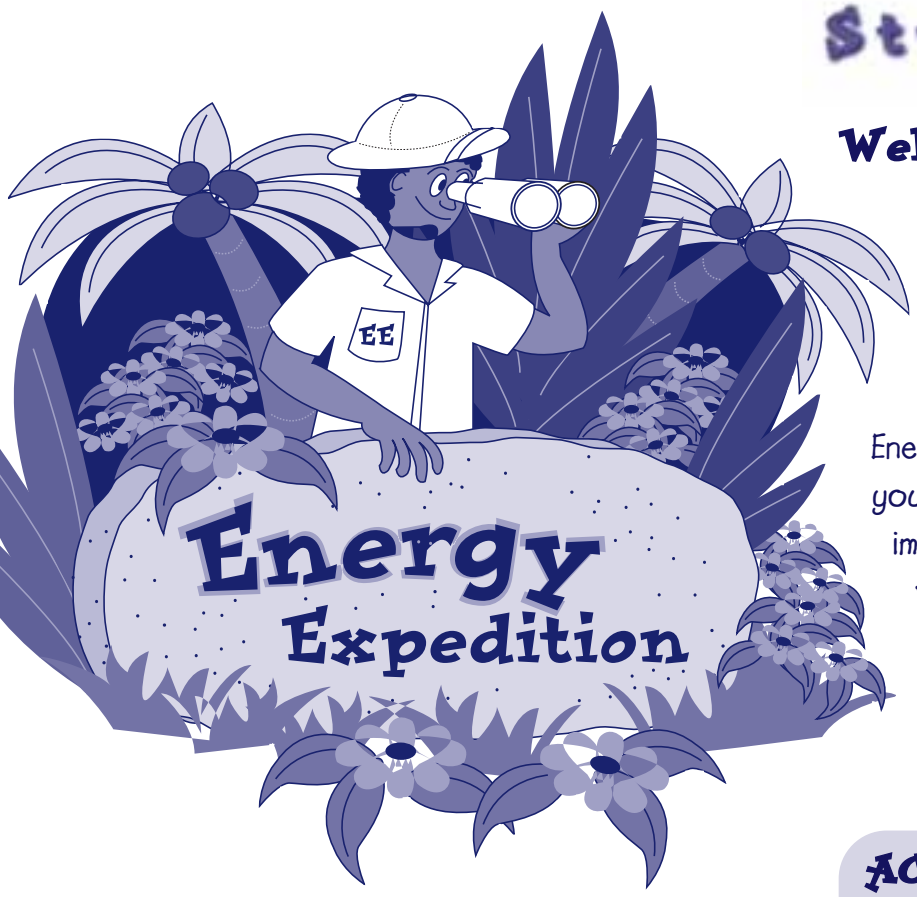


ACROSS

1. A type of energy. The word describes something that's "possible, but not certain." potential
4. The process of burning a material or substance. It's another word for "incineration," and its letters might "bust!" combustion
6. A liquid that we can control and direct to generate energy. You might drink it or swim in it. water
7. A substance that is neither liquid, nor solid, but can be removed from the Earth and used to generate power. gas
8. A hard, black substance that we burn for fuel. coal
10. A word describing energy from the sun. It rhymes with "polar." solar

DOWN

2. It's another word for unwanted material that you throw out into a container every day. You might set it out on the curb or throw it in a dumpster. trash
3. The hard rock-like remains of prehistoric animal and plant life, such as dinosaurs, which we sometimes discover in the Earth's crust. fossil
5. A natural gas that is generated by garbage decomposing in a landfill. Live animals can produce this gas as well...such as a cow burping! The word ends in "ane," but it's not "propane." methane
9. The liquid that we pump from the Earth's surface to burn for fuel. This work also applies to a product we often use in cooking. oil

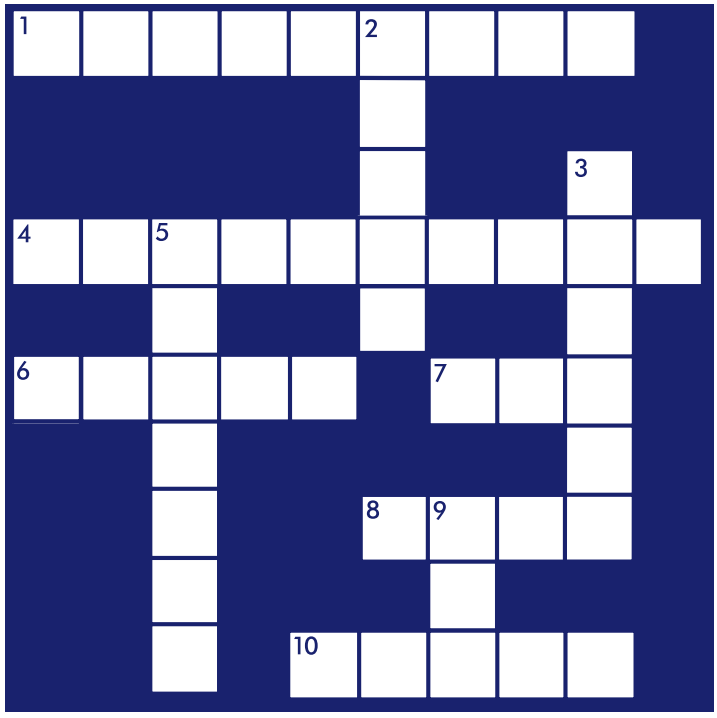


Welcome Energy Explorer!

You're about to set out on a mission to investigate ENERGY, including its uses, sources, and connection to our trash. If you accomplish your mission, you'll be promoted to an Energy Expert—and you'll be able to help your family and friends understand how important energy is to them and their way of life. This mission is not easy, however, and it will take all of your concentration and effort to crack the energy mystery. Good luck!

Name:_____

Directions: Your first task is to complete the Energy Crossword Puzzle below using the clues provided. Once you have filled in the crossword puzzle, you'll have a list of ten important energy vocabulary words.



ACROSS

1. A type of energy. The word describes something that's "possible, but not certain." _____

4. The process of burning a material or substance. It's another word for "incineration," and its letters might "bust!" _____

6. A liquid that we can control and direct to generate energy. You might drink it or swim in it. _____

7. A substance that is neither liquid, nor solid, but can be removed from the Earth and used to generate power. _____

8. A hard, black substance that we burn for fuel. _____

10. A word describing energy from the sun. It rhymes with "polar." _____

DOWN

2. It's another word for unwanted material that you throw out into a container every day. You might set it out on the curb or throw it in a dumpster. _____

3. The hard rock-like remains of prehistoric animal and plant life, such as dinosaurs, which we sometimes discover in the Earth's crust. _____

5. A natural gas that is generated by garbage decomposing in a landfill. Live animals can produce this gas as well...such as a cow burping! The word ends in "ane," but it's not "propane." _____

9. The liquid that we pump from the Earth's surface to burn for fuel. This word also applies to a product we often use in cooking. _____

Energy Story

Directions: Great job! You've now learned ten important energy vocabulary words! Read the story below to learn more about energy and become an Energy Expert. You must determine which of your ten vocabulary words goes in each blank. Remember, some words will be used more than once. After you have filled in all of the blanks, you'll have successfully completed your energy mission!

What is ENERGY?

Energy is one of the most important parts of our world—it makes things happen. Energy means the "ability to do work." Did you know that you use energy every day? Every time you flip a light switch on; use hot water; or ride in a car, bus, train, or plane, you are using energy. Each time you watch TV or use a computer, you are using energy. All of the clothes that you wear, toys you play with, and food you eat are products made from processes that require energy.

There are two different types of energy:

- Energy that is stored is called _____ energy.
- Energy that is moving is called kinetic energy.

Let your pencil rest on your desk. Right now, if it's not moving, your pencil has_____**(same as previous blank)** energy. Now, tap it lightly so that it rolls across your desk. Since it's moving, the pencil now has kinetic energy.

Where does ENERGY come from?

There are many different sources of energy on Earth and there are many different ways that we can tap into those sources and make the energy work for us—creating power, electricity, and heat.

One source of energy upon which we rely heavily are_____ fuels. How were these fuels formed? Millions of years ago, ancient plants absorbed the energy from the sun and converted it into more plants. Ancient animals, like dinosaurs, ate the plants and converted the plant's energy into body mass. When the animals and dinosaurs died, their remains collected in the ground, and, over millions of years, decomposed into a source of fuel.

What are some_____ **(same as previous blank)** fuels? Coal, oil, and natural gas are three important fuels that are derived from the Earth and the stored energy of organic remains.

_____ started out as a spongy, brown material called "peat," which consists of the decomposed organic matter of ancient animals and plants. Geologic forces buried the peat deep under the Earth's surface, where it was further packed down by heat and pressure. The compressed peat was eventually converted to_____**(same as previous blank)**.
We burn_____ **(same as previous blank)** to heat our homes and run electrical machinery. About 20 percent of the energy we use comes from _____**(same as previous blank)**.

_____ is formed deep within the Earth's surface in rocks that are fine-grained and rich in the organic remains of once-living animals. The oldest_____**(same as previous blank)** -bearing rocks date back more than 600 million years. _____ **(same as previous blank)** is burned to fuel vehicles and heat homes. About 45 percent of the energy we use comes from _____**(same as previous blank)**.

Natural _____ is a colorless, odorless fuel produced by drilling into the Earth's crust where it was trapped hundreds of thousands of years ago. Once it is brought to the surface, it is refined and purified to remove water, other gases, and sand. Next, it's transported through large metal pipelines that span the continent. Natural _____ **(same as previous blank)** is used for heating, cooling, and the production of electricity.

How is ENERGY connected to trash?

While these sources of energy continue to serve us well, they are known as nonrenewable resources that will eventually be used up. Once we use all of our supplies, we will have to depend on new sources of energy. We're already looking for new energy sources so that we can conserve those that come from within the Earth. That's where_____ comes in. Did you know that you can get energy from _____**(same as previous blank)**? There are two ways that we can use our_____ **(same as previous blank)** to make energy.

In one method,_____**(same as previous blank)** is taken to a waste-to-energy facility. These facilities burn the _____ **(same as previous blank)** during a process called_____. This process generates heat that can be converted to fuel and electricity. Waste-to-energy facilities take a large amount of trash and make it smaller by burning it. This reduces the amount of trash that piles up in our landfills, which is better for the environment.

A second way for us to use trash for energy involves the garbage that we dispose of in landfills. As this trash decomposes, it produces _____ gas. Too often, this valuable source of energy is not used. Now, however, over 150 landfills in the United States are using the gas, captured by a special pipe system set up in the landfill, to generate electricity; provide fuel for factories, schools, and other facilities; and to produce natural gas for general distribution.

Are there any other sources of ENERGY?

In addition to using the energy we generate from our garbage, there are other ways we can harness the renewable energy sources that surround us. Here are two other important energy sources that we are just beginning to use in place of fossil fuels.

The light that comes to the Earth from the sun is pure energy. Nearly all other sources of energy originally got their energy from the sun. Organic matter, like plants, convert _____ energy into leaves, flowers, and fruits. We can also use energy from the sun to heat our homes and buildings with special _____ **(same as previous blank)** panels that capture and convert the light into energy.

Hydroelectric power is generated by harnessing _____. When _____ **(same as previous blank)** falls or runs downhill, it can be used to run turbines or large water wheels at mills and factories, which generate electricity.

Now you understand how our trash can help us generate power and electricity. In addition, you've learned all about our use of energy on this planet and the many different sources we can turn to for energy use in the future.

The Great Disposal Debate

Objective

To teach students about some of the environmental, social, and economic issues surrounding modern landfills, incinerators, and other forms of waste management.

Activity Description

Students will research and debate the pros and cons of using landfills for waste disposal and energy generation, and then compare with other forms of waste disposal and energy generation.

Materials Needed

- Index or note cards for each student
- Internet, library, encyclopedia, or other access to research resources
- Background information from Teacher Fact Sheets and other resources listed below

Key Vocabulary Words

Decomposition
Greenhouse gases
Ground water
Incinerator
Landfill
Leachate
Methane

Duration

Day 1: 1 hour
Day 2: 1 hour

Skills Used

Research
Reading
Problem solving
Communication

Activity

Day 1

Step 1: Introduce the concept of the modern landfill and explain some of the advantages and disadvantages to this form of waste disposal. (Refer to the Teacher Fact Sheets titled *Landfills* on page 165, *Combustion* on page 169, *Solid Waste* on page 47, and *Hazardous Waste* on page 51 for background information. Teachers may also choose to use the History Channel's video, *Modern Marvels: Garbage*, which provides information on sanitary landfills and the history of garbage; contact (800) 941-4007 or <www.AandE.com> for more information.)

Step 2: Once the students understand the above concepts, divide the class into two groups: Pros and Cons.

Step 3: As a homework assignment or an in-class teacher-led group activity, have students conduct research and come up with at least three points or arguments defending their side of the debate (i.e., pros or cons associated with landfills). Encourage students to use the school library, Internet, or other resources, such as contacting the regional solid waste agency or local recycling coordinator. Teachers may also choose to provide students with Enviroscapes' Landfill Model, which compares old garbage dumps to modern sanitary landfills. For more information, email <info@enviroscapes.com> or visit <www.enviroscapes.com>.

Journal Activity

Ask students to think about the advantages and disadvantages associated with landfills. Which one issue is most important to them? Why?

Day 2

Step 1: On day two, have the two sides regroup to discuss what they discovered through their research. Give each group 15 to 20 minutes to work together and prepare their side of the debate on either the pros or cons of landfills. During that time, ask the students to combine their note cards and assemble them in order of importance for easy reference during the debate. Instruct students to pick four classmates to represent the group as the debaters.

Step 2: Explain that each team will get 5 minutes to present their side of the debate. During that time, any of the four designated debaters for that team can speak, but they must take turns. After one side presents, the other team has 5 minutes to present their points.

Step 3: After the formal debate is over, allow each team to respond to one or more of the issues raised by the other group. The teacher may choose to serve as a moderator during this question and answer session.

Step 4: At the end of the debate ask the students if they were persuaded by either side and why.

Assessment

1. Ask the students to discuss/explain whether or not they would want a landfill in their community. Why or why not?
2. How does the debate change if the landfill is used for electricity generation? Does this benefit outweigh some of the negatives? Does this change the students' opinions/ perceptions of landfills?

Enrichment

1. Have students create a survey and conduct interviews with family members or friends to determine how other people feel about landfills. Compile, analyze, and discuss the results of the surveys in class. Make graphs or charts based on these results.
2. Have each student group research how garbage was disposed of in Medieval times, the 1800s, and early 1900s. How does this compare to today's disposal methods? Have one group of students research how garbage is disposed of today in countries other than the United States. Ask the students how they think garbage may be handled in the future.
3. Take a field trip to a local landfill to tour the facility and learn how it works. When you return, have the students write a paragraph on their visit, including five new facts.
4. Explore the issues of greenhouse gases and global climate change in more depth. Use the example of capturing methane from landfills for energy as one way to help reduce greenhouse gas emissions. Ask the students to think of other ways we might reduce greenhouse gases. Examples include using less electricity, creating less garbage (see section on *Source Reduction*), improving technologies to cleanup power plants emissions, and planting trees. (See EPA's Web site on methane, <www.epa.gov/methane/index.html>, and global warming, <www.epa.gov/globalwarming>, for reference information.)

A Look at Landfills

Pros

- Gives us somewhere to put our solid waste.
- Is more protective than dumps of the past.
- Waste decomposition at a landfill generates methane—a potent greenhouse gas that can be captured and used for energy.
- Converting methane to energy can help reduce greenhouse gas emissions—directly, by capturing methane from the landfill, and indirectly by serving as an alternative energy to fossil fuels.
- Can be properly capped and use for park land, playgrounds, or other nonresidential purposes.
- Can provide a source of jobs and income for a town or state that is willing to accept solid waste from other cities, towns, or states for a fee ("host fees").
- Using a local or nearby landfill can cut down on fuel emissions from trucks and boats carrying waste to faraway areas.

Cons

- Can cause noise and traffic with trucks driving to and from the landfill.
- Must be designed and constructed to prevent contamination of ground water, surface water, and soil.
- Can lead to bad smelling (rotten egg) or unhealthy air.
- If not properly capped and managed, can attract birds and pests.
- May lower the property values of the surrounding area.
- Shipping waste to a landfill in another state or county may lead to dust problems or blowing trash if not covered properly.
- Loose garbage can blow around if landfill is not properly capped and managed.

Greenhouse Gases Be Gone

Objective

Educate students about the differences in greenhouse gas emissions as they relate to different forms of waste and waste disposal methods.

Activity Description

Students will research various forms of waste disposal and use EPA's Waste Reduction Model (WARM) to calculate greenhouse gas emissions associated with waste and waste disposal methods.

Materials Needed

- EPA's Waste Reduction Model (WARM) (available at EPA's Global Warming Web site: http://yosemite.epa.gov/OAR/globalwarming.nsf/content/ActionsWasteWARM.html
- Computer (with Internet access or Microsoft Excel)
- EPA's Web site on Climate Change and Waste: http://yosemite.epa.gov/oar/globalwarming.nsf/content/ActionsWaste.html
- Pencils
- *Weekly Waste Generation Tracking Sheets*
- Library

Key Vocabulary Words

Carbon dioxide
Emissions
Global climate change
Greenhouse gases
Recycling
Solid Waste
Source reduction

Duration

3 hours (in class)

Skills Used

Computation
Observation/Classification
Research
Reading
Problem Solving

Activity

Part 1

Step 1: Review the various methods of handling waste (including source reduction, recycling, landfilling, composting, and incinerating) using the Teacher Fact Sheets titled *Source Reduction* on page 79, *Recycling* on page 101, *Buying Recycled* on page 107, *Composting* on page 141, *Landfills* on page 165, and *Combustion* on page 169. Define greenhouse gases and explain how the various factors of waste disposal (type of waste, type of disposal, transportation) affect greenhouse gas emissions and thus global climate change. (For information on the connection between waste and climate change see EPA's Web site at <http://yosemite.epa.gov/oar/globalwarming.nsf/content/ActionsWaste.html>.)

Step 2: Hand each student a *Weekly Waste Generation Tracking Sheet* and ask them to fill it out every day for one week. Have the students take the sheet home every evening to record their waste generation at home. Remind them to include the materials they use both in

school and home, such as drink cans and cartons, lunch bags, and looseleaf and printer paper.

Step 3: During this same week, have students research how each type of waste (e.g., aluminum, food scraps, newspaper) is normally disposed of, particularly in their town or county. (Tip: You may want to assign one specific waste to individual groups of students.) Teachers will use this information to enter data into the baseline scenario of EPA's Waste Reduction Model (WARM).

Two Methods for Gathering Information

Teachers may choose between two methods for gathering the necessary information to input into WARM (Part 1, Step 2):

- ***Simpler***—Students will track the amount of each material type they dispose of each day. The teacher will use this information (as directed Part 2, Step 3) as baseline data and then try different combinations of alternative waste disposal methods in WARM and discuss the results with the class.
- ***Complex***—Students will track both the amount of each material type they dispose of each day and the method of disposal (throw out, recycle, compost). The teacher will use this information as directed Part 2, Step 3 to complete the WARM spreadsheets.

Part 2

Step 1: The following week collect the *Weekly Waste Generation Tracking Sheets* from the students and tally the results into one combined tracking sheet. This represents the weekly waste generation for the class. In order for the WARM tool to give meaningful results, however, the class will need to take the weekly waste generation information and project the total waste generation (by commodity) for the class for the year. (Depending on the size of the class, teachers may need to take this one step further and project the yearly waste generation for the school.) Convert this number into tons for input into WARM.

Step 2: Review the discussion on greenhouse gases and their relationship to waste and waste disposal (as described in Part 1: Step 1).

Step 3: Access EPA's WARM calculator at <http://yosemite.epa.gov/oar/globalwarming.nsf/content/ActionsWasteWARM.html>. Explain that this tool is often used by solid waste planners and organizations to track, report, and estimate the effects of various waste disposal methods on greenhouse gas emissions. The model calculates greenhouse gas emissions for baseline and alternative means of waste management. Discuss how people can use models to predict possible future scenarios, such as the effect of certain activities on air or water pollution, or a new street layout on rush hour traffic conditions. Enter the information for baseline data as gathered by the class. (Teachers can enter data into the online spreadsheets and print out the results but cannot save them. Therefore, teachers may choose to download the Microsoft Excel file, which can be saved.)

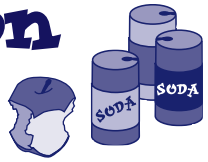
Step 4: Working with the students, enter data into the alternative management scenario and complete the WARM spreadsheet. Review and discuss the results of various waste management practices on greenhouse gas emissions. Ask the class to observe whether the alternative management scenario reduced the amount of emissions. Why or why not? Try incorporating different waste management practices to view the effects on emissions and discuss the results with the class.

1. Ask the students what they learned from using the tool and how this might be applicable to the real world. How might communities use tools such as WARM to help manage their waste and minimize their impacts on global climate change?

1. Contact a local solid waste planner or organization and ask them to fill out WARM. Had they heard of this tool before? How did their baseline and results compare with the class?
2. How do greenhouse gas reductions achieved with alternative waste management methods relate to real life? Equivalency calculators convert emissions or energy use reductions into more understandable terms, such as number of cars removed from the road or acres of trees planted. Use the information generated by the class and WARM to complete the *Greenhouse Gas Equivalencies Calculator* available at <www.usctcgateway.net/tool/> or other tools available at <http://yosemite.epa.gov/OAR/globalwarming.nsf/content/ActionsWasteTools.html>. Discuss the results.

Student Handout

Weekly Waste Generation Tracking sheet



Name: _____ Enter the amount of each item that you discard each day.

Material	Day 1	Day 2	Day 3	Day 4
Aluminum Cans				
Steel Cans				
Glass				
HDPE (plastic)				
LDPE (plastic)				
PET (plastic)				
Mixed Plastics				
White (printer) Paper				
Textbooks				
Magazines				
Newspaper				
Food Scraps				
Grass				
Leaves				
Yard Trimmings				
Mixed Paper (general)				
Mixed Metals				
Mixed Recyclables				

Name: _____ Enter the amount of each item that you discard each day.

Material	Day 5	Day 6	Day 7	Total
Aluminum Cans				
Steel Cans				
Glass				
HDPE (plastic)				
LDPE (plastic)				
PET (plastic)				
Mixed Plastics				
White (printer) Paper				
Textbooks				
Magazines				
Newspaper				
Food Scraps				
Grass				
Leaves				
Yard Trimmings				
Mixed Paper (general)				
Mixed Metals				
Mixed Recyclables				